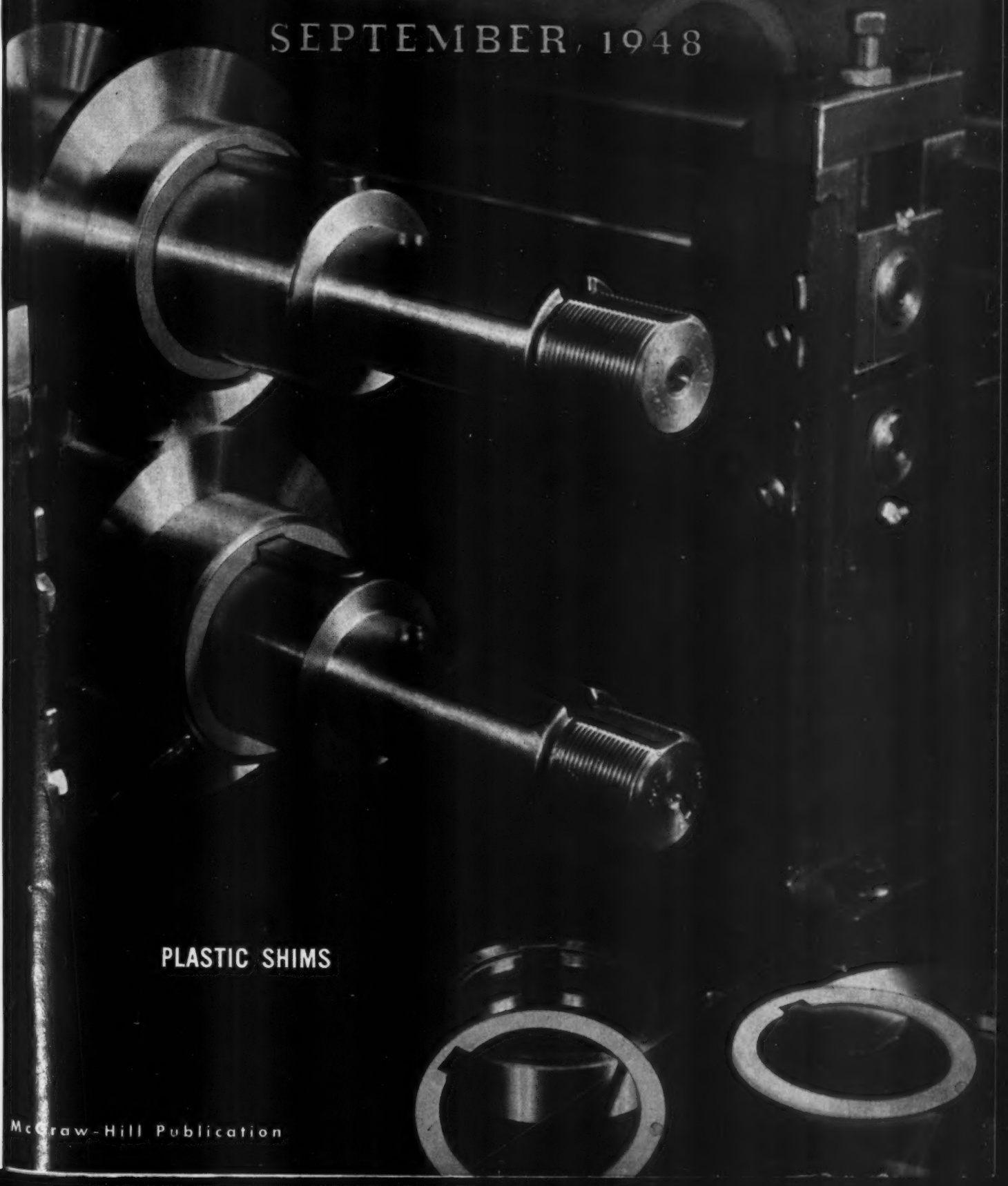
SEP 13 '48

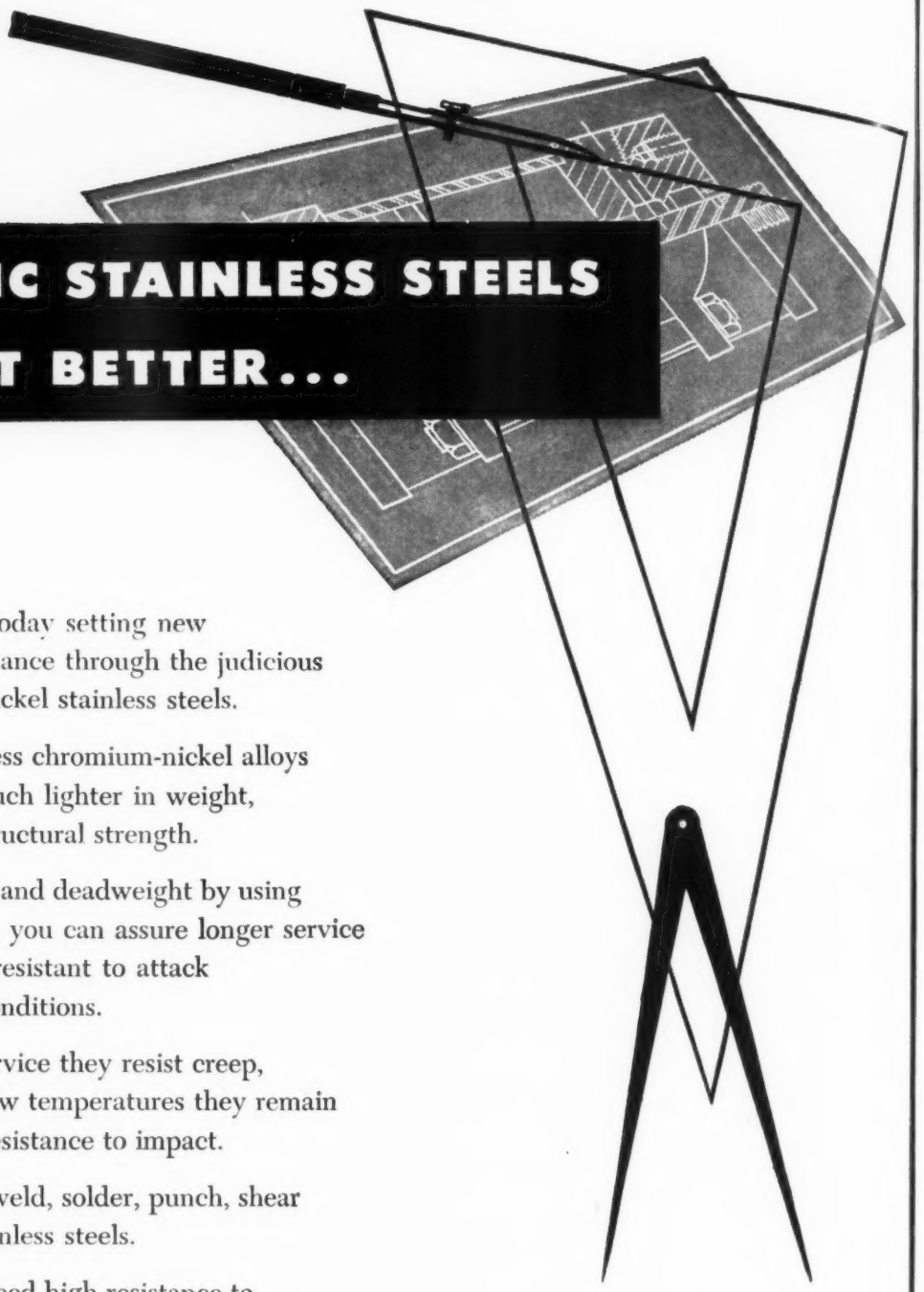
PRODUCT ENGINEERING

SEPTEMBER, 1948



PLASTIC SHIMS

McGraw-Hill Publication



AUSTENITIC STAINLESS STEELS MAY DO IT BETTER...

Hundreds of companies are today setting new standards of low-cost performance through the judicious use of austenitic chromium-nickel stainless steels.

By redesigning these stainless chromium-nickel alloys often permit making parts much lighter in weight, while still providing ample structural strength.

Not only can you trim bulk and deadweight by using chromium-nickel stainless . . . you can assure longer service life because these alloys are resistant to attack by nearly all oxidizing acid conditions.

In elevated temperature service they resist creep, scaling or oxidation, and at low temperatures they remain tough and offer exceptional resistance to impact.

You can draw, spin, forge, weld, solder, punch, shear or bend chromium-nickel stainless steels.

They are used where you need high resistance to corrosion and heat, along with good resistance to impact, wear and abrasion. They assure long, trouble-free performance of equipment, the appeal of beauty and durability in decorations, hygienic cleanliness as well as economy in food, drug, chemical and other process industries.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

EMBLEM OF INCO SERVICE

TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall St., New York 5, N. Y.

VOLUME 19 — PRODUCT ENGINEERING — NUMBER 9

G. F. NORDENHOLT, *Editor*
Assistant to the Editor, Joseph Kerr • *Managing Editor,* James R. Bright • *Associate Editors,* Harold Schor, E. W. Schlieben, L. P. Tolman, V. H. Laughner • *Assistant Editors,* R. A. Wason, E. S. Cobb, N. J. Van Ness
Consulting Editor, Robert E. Bruckner • *Washington,* George E. Doying, Jr
Publisher, Albert Hauptli • *Assistant Publisher,* W. E. Kennedy
Foreign News Bureau: London • Paris • Berlin • Moscow • Tokyo • Bombay • Melbourne • Rio de Janeiro • Buenos Aires.

SEPTEMBER 1948

Product Development Responsibilities by J. B. Davis and M. M. Brandt. 81
The engineer's responsibilities in the design and manufacture of a commercially successful product.

Vibration Isolation and Shock Mounting by Carl J. Bastien. 86
Practical discussion of the vibration and shock problem.

Product Designs 90
Electric resistance heater, Hydraulic control system, Hot water heating systems, Paper cutter.

Nonferrous Metal Powders by D. C. Bradley 102
Physical characteristics and mechanical properties of nonferrous metal powders.

Embrittlement of Assembled Roller Chains by Plating 105
Reasons why electroplating assembled precision steel roller transmission chain sometimes causes failure.

Thermostatic Bimetal by Ernest R. Howard. 106
Load and deflection formulas and time response characteristics of a number of types of bimetal.

Torsion Bar Springs by Donald Bastow 111
Basic formulas for stress distribution and energy storage in types of torsion bars.

Pressure Drop Losses in Tubes by Domenic A. DiTirro 117
Two charts to simplify pressure drop calculations for fluid flow through straight smooth pipes.

Tensile Testing of Steel Roller Chain 121
Design of grip jaws and procedure for testing standard steel roller chain.

Metal Stamping Design for Economy in Production 122
Production factors designers should understand when designing stamped parts.

Simplified Polariscope for Industrial Use by Ray W. Clough. 124
Construction details for a useful stress analysis tool.

Plastics as Engineering Materials 129
Special 24-page report explains successful engineering with plastics in a wide variety of products.

Chart For Determining Properties of Round Aircraft Tubing by Benjamin Ostlind. . . 165
Gives cross-sectional area, moment of inertia and radius of gyration of structural tubing.

Nomogram for Designing Steel Torsion Springs by Carl P. Nachod. 167
Data are included for making nomograms for use in design of torsion springs of other metals.

FRONT COVER — Cellulose acetate shims give accurate spacing on a Yoder No. 336 slitting machine. See "Plastics as Engineering Materials," page 129. Kodachrome by L. R. Johnson, Camera Craft Studio, Cleveland, Ohio.

DEPARTMENTS

Highlights 3
Editorial 79
Engineering Abstracts . . . 153
Technical News 158
Washington Notes 161
New Materials and Parts. 171
New Books 184
Our Readers Say. 194

Publication Office: 99-129 North Broadway, Albany 1, N. Y. **Return postage guaranteed.**
Published Monthly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder; James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Executive Assistant for Publications; Nelson Bond, Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn, Jr., Director of Circulation.
Correspondence About Subscriptions should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.
Subscription Rates: Single copies 75¢, United States and possessions, $6 for one year, $9 for two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
Editorial and Executive Offices: 330 W. 42nd St., New York 18, N. Y. Cable address: "McGraw-Hill, New York."
Branch Offices: ATLANTA, R. M. Maultsby, 1011 Rhodes-Haverty Bldg.; BOSTON, John H. Koch, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Ray Deen, Anson E. Meanor, 520 N. Michigan Ave.; CINCINNATI, R. H. Anderson, 1110 Delta Ave.; CLEVELAND, A. F. Tischer and R. H. Anderson, 1510 Hanna Bldg.; DETROIT, G. P. Weatherby, 2089 Penobscot Bldg.; LOS ANGELES, C. W. Dysinger, 622 S. Hope St.; NEW YORK, J. A. McGraw, Hugh Britton, 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg., 17th and Sansom Sts.; PITTSBURGH, 738-9 Oliver Bldg.; ST. LOUIS, Continental Bldg.; SAN FRANCISCO, J. W. Otterson, 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.
Entered as second-class matter Aug. 21, 1936, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U.S.A. Members of A.B.P., A.B.C. Copyright 1948 by McGraw-Hill Publishing Co., Inc. All rights reserved.

MALLORY ORIGINATED ELKONITE* METALS—

ELKONITE

and only Mallory has the years of experience with their complex fabrication

ELKONITE is the registered trade mark for a series of metals originated by Mallory which derive their effectiveness from the skillful compounding that Mallory has developed through many, many years of pioneering in the field of powder metallurgy.

Elkonite metal proved so dependable under the most severe conditions that it quickly became standard on most heavy duty circuit interrupting equipment. It also proved indispensable in the field of resistance welding and in countless applications requiring its particular characteristics.

The success of Elkonite metal is so well established that the trade mark has been mistakenly applied to materials that are sold with the implication that they will match the performance of true Elkonite metal.

Mallory has made true Elkonite metals for years. Only Mallory can guarantee the correct formulation that gives hardness, high electrical conductivity, resistance to mechanical wear and to sticking and erosion by arcing—the qualities that have made the word Elkonite a symbol of dependability.

ONLY MALLORY MAKES AND SELLS GENUINE ELKONITE METAL

**Reg. U. S. Pat. Off.*

P. R. MALLORY & CO. Inc.

MALLORY ELECTRICAL CONTACTS & CONTACT ASSEMBLIES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Management Sorely Needs Engineers

WHO SHALL BE RESPONSIBLE for the cost of the finished product? The tendency today is to load it all on the engineering department, specifically the chief engineer. This is sometimes accompanied with demands for lower engineering costs, and added sales features in the product, as well as lowered manufacturing cost. In attempting to analyze the forces that impel such often unreasonable demands, one is forced to the conclusion that they are but a reflection of the economic and labor conditions under which industry is operating.

Lower cost per unit produced at higher wage rates can be achieved only through design, purchasing, and increased production efficiency. The last borders on the impossible because of the labor situation. Even the expected economies of design simplification are sometimes erased by soldiering or feather bedding. In too many factories the will to work does not extend beyond, "five hundred bricks per day", although the conditions are reported to be improving.

With no avenue open for reducing costs appreciably, other than design economies, management naturally puts the squeeze on the engineering department, which is perhaps as it should be.

Unfortunately, too many management executives have little or no understanding of technical design problems. If they are demanding perpetual motion they don't know it, and even if they do, it wouldn't have any significance to them. "You have got to do it somehow!" is an oft heard expression.

As one design executive put it, "Management is long on demands for end results, but devoid of ideas on how to get there." Such absence of leadership and unreasonable demanding, is not constructive, contributes nothing to accomplishment and often results in demoralization.

Cost reduction is not any one person's job. It is greatly affected by the morale of the employees, the spirit of cooperation between all of the departments, and the ability of management to get the men to give their best.

The present critical situation in which the inflation spiral is approaching the point where products are being priced out of their market is a severe test for all concerned. It also emphasizes the dire necessity of having a top management that is thoroughly grounded in all phases of the business, namely design and production as well as sales, purchasing and financing. That is why there is a wonderful opportunity for design and production engineers today. They are sorely needed in the councils of top managements, not as subordinates but as directors.

In the meantime, brow beating the chief engineer to achieve results that are impossible is not going to contribute to progress or success.

G. F. Rodenholt

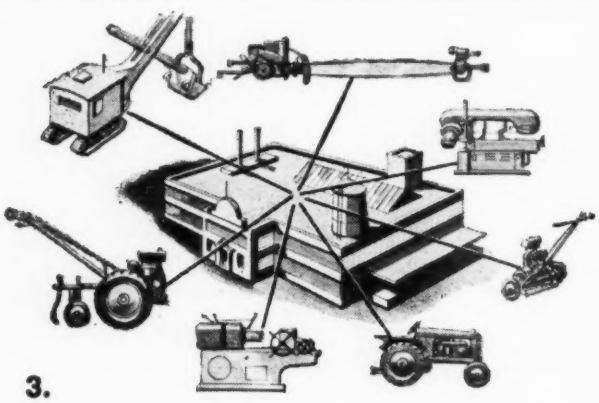
Let Morse grease the rails for your tough jobs too!

1.

Sc-r-r-ee-ch! Railroad men know this noise means that expensive train wheels and rails are wearing away on curves. To prevent this wear, automatic greasers were installed to lubricate wheels and rails. Old-style ratchet type clutches were tried, but slipped or didn't feed grease right. American Brake Shoe Company's Ramapo Ajax Division solved this knotty problem . . .

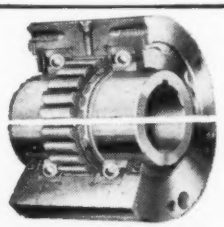
2.

They now use Morse-Formsprag Clutches. The positive action of Morse-Formsprag Clutches is far superior in performance, dependability and service over the old ratchet type. *M-F Clutches engage instantly; allow no back-slip; feed grease to every passing wheel.* Other complex operations on your products may call for Morse-Rockford Friction Clutches . . .

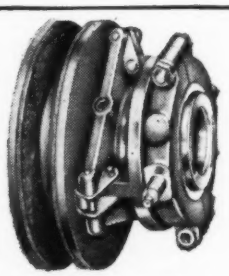


3.

Morse clutches fill almost every need you can imagine. Can the sales and mechanical value of your own products be enhanced by using Morse clutches? Leading manufacturers of such items as construction equipment, cultivators, saws, pumps, lawn mowers and machine tools have bettered *their* products with Morse clutches. How about you? Do this now . . .



Morse-Formsprag Full Complement Over-Running Clutches



Morse-Rockford Over-Center Small Diameter Clutches

Morse Pullmore Friction Clutches

4.

Write for expert clutch engineering aid and consultation. For new ideas, send for clutch catalogs: Morse Formsprag Clutch Catalog, No. C11-48; Morse Pullmore Clutch Catalog, C31-47; Morse-Rockford Clutch Catalog, SDOC. Address: Morse Chain Company, Department 221, 7601 Central Avenue, Detroit 8, Michigan.

Morflex Couplings

Roller Chain Couplings

Silent Chain Drives

MORSE

MECHANICAL POWER TRANSMISSION PRODUCTS

A PRODUCT OF BW BORG-WARNER

Morflex Radial Couplings

MORSE CHAIN COMPANY • DETROIT 8, MICHIGAN

Engineering Responsibilities In Creating New Products

When evolving a new product within a large manufacturing company, engineers must integrate their individual skills as part of a complex organization. A workable system of coordinating engineering responsibilites is vital to efficient product development.

J. BURGESS DAVIS
Editor
MULFORD M. BRANDT
Staff Assistant
Engineering Administration,
RCA Victor Division,
Radio Corporation of America

THE CYCLE of evolving a new product generally starts with a survey of the market by the sales department.

Once the market has been determined and the estimated consumer requirements have been decided upon, the proposed product is usually discussed by a committee composed of representatives of the Sales, Engineering, and Manufacturing Departments. If, after considering such factors as technical feasibility, quantity, manufacturing facilities, availability of materials, and costs and profits, it is decided that the product should possibly be produced; a cost estimate will be requested of both Engineering and Manufacturing Departments. If the estimates are acceptable to the Sales Department, recommendations for developing, designing, and manufacturing the product may be made to the top management of Sales, Engineering, and Manufacturing Departments. If management approves the recommendations, the Sales Department will issue an authorization, Fig. 1, to Engineering and Manufacturing Departments to proceed with the work.

Such products are manufactured in stated quantities, listed as catalogued stock, and stored in warehouses to be sold as the demand is created.

Sometimes the engineering cycle starts with the request, or invitation, to bid for a product not included in catalogued stock. When the customer's requirements have been determined, the engineer, at the request of the Sales Department, may prepare a written description of the product or service to be contracted for. Purpose of a "descriptive specification" is to insure complete understanding between the customer, the sales personnel, and the engineering personnel. If the descriptive specification and terms are acceptable to the customer, the Sales Department will, upon receipt of an order, authorize the Engineering Department to proceed with the development of the product or service required. Charges for this type of engineering are usually the result of sales negotiation and are usually liquidated in the sale to the customer.

Generally the engineering phases in the evolution of a new product include:

1. Research phase—principles of a new idea or invention are proven and conceived to be applicable to a product.

2. Advanced development phase—

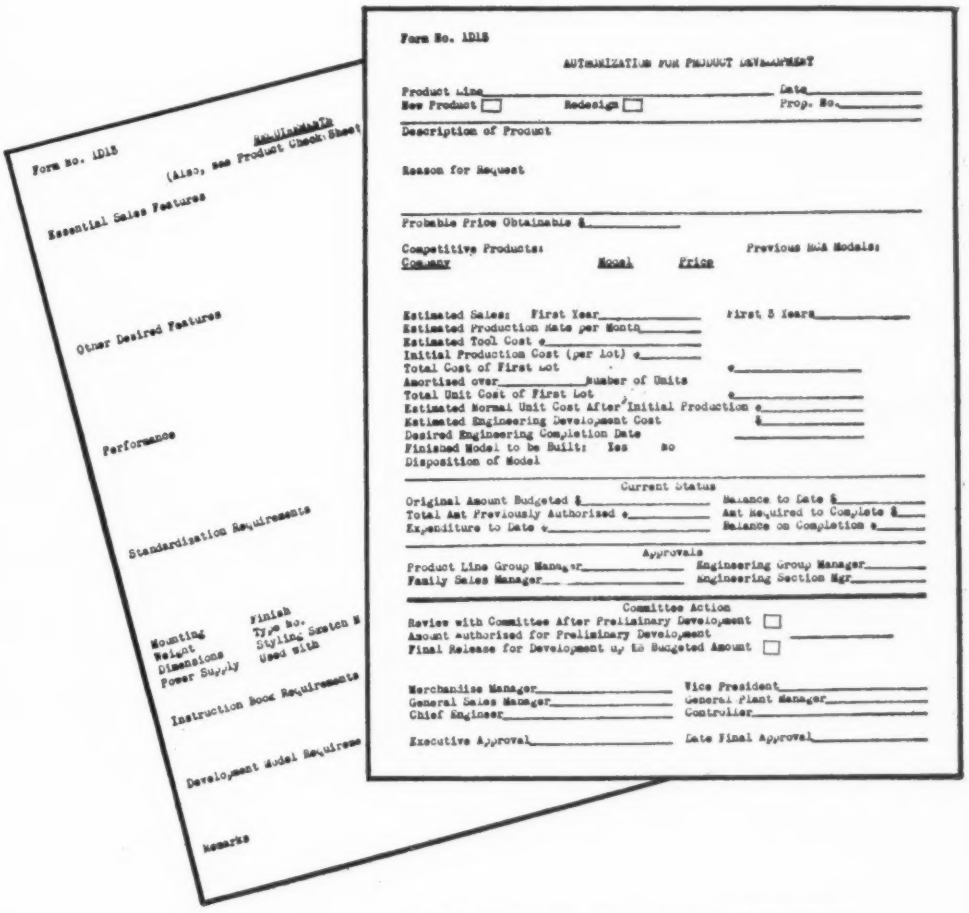
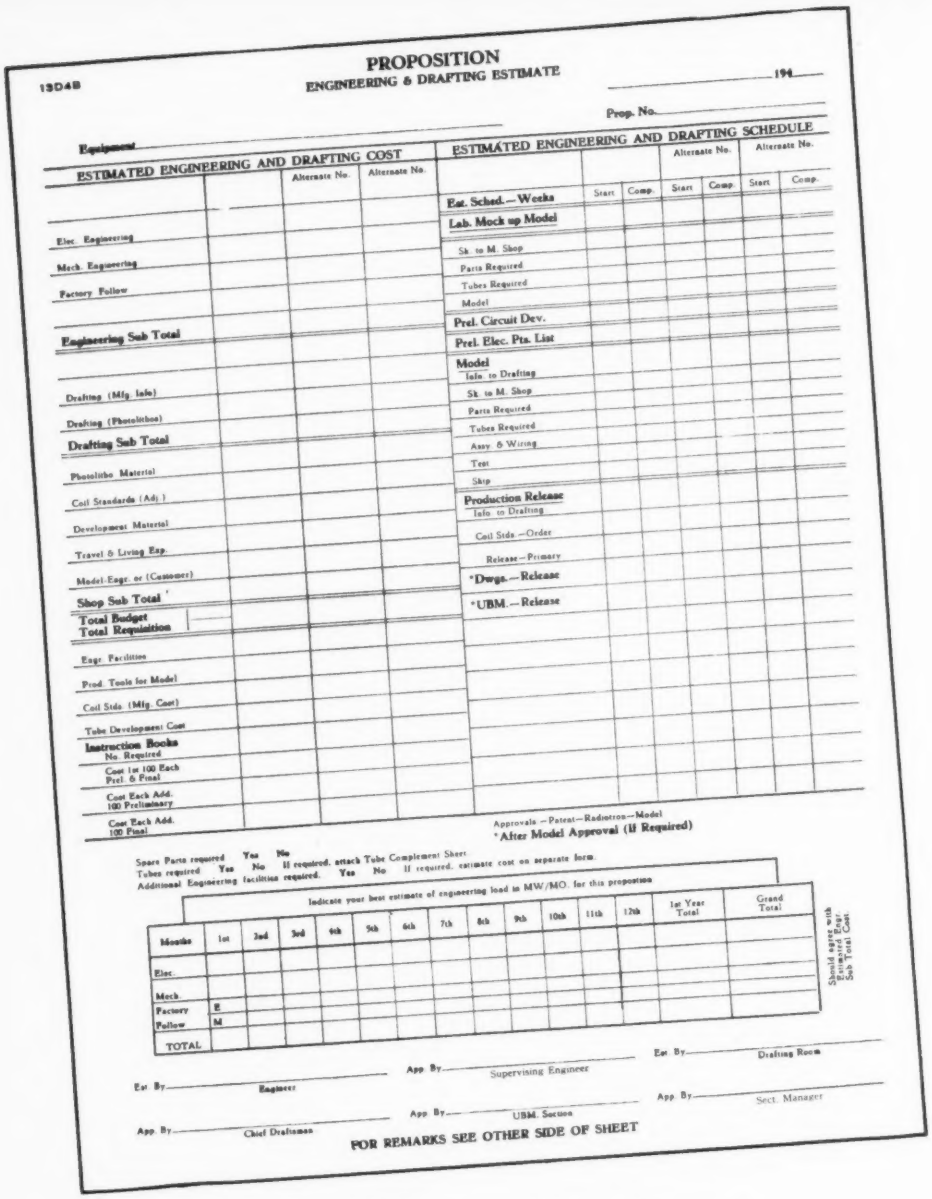


Fig. 1—Before the product development phase is started at RCA, this form must be approved by engineering and sales managers.



PROPOSITION
ENGINEERING & DRAFTING ESTIMATE

13D4B

194

Prop. No.

Equipment

ESTIMATED ENGINEERING AND DRAFTING COST

		Alternate No.	Alternate No.
Elec. Engineering			
Mech. Engineering			
Factory Follow			
Engineering Sub Total			
Drafting (Mfg. Info)			
Drafting (Photolitho)			
Drafting Sub Total			
Photolitho Material			
Coil Standards (Adj.)			
Development Material			
Travel & Living Exp.			
Model-Engr. or (Customer)			
Shop Sub Total			
Total Budget			
Total Requisition			
Engr. Facilities			
Prod. Tools for Model			
Coil Stds. (Mfg. Cost)			
Tube Development Cost			
Instruction Books No. Required			
Cost 1st 100 Each Prel. & Final			
Cost Each Add. 100 Preliminary			
Cost Each Add. 100 Final			

ESTIMATED ENGINEERING AND DRAFTING SCHEDULE

	Alternate No.		Alternate No.		Alternate No.	
	Start	Comp.	Start	Comp.	Start	Comp.
Est. Sched.—Weeks						
Lab. Mock up Model						
Sk. to M. Shop						
Parts Required						
Tubes Required						
Model						
Prel. Circuit Dev.						
Prel. Elec. Pts. List						
Model						
Info. to Drafting						
Sk. to M. Shop						
Parts Required						
Tubes Required						
Assy. & Wiring						
Test						
Ship						
Production Release						
Info. to Drafting						
Coil Stds.—Order						
Release—Primary						
*Dwgs.—Release						
*UBM.—Release						

Approvals—Patent—Radiotron—Model
*After Model Approval (If Required)

Spare Parts required Yes No
Tubes required Yes No If required, attach Tube Complement Sheet
Additional Engineering facilities required. Yes No If required, estimate cost on separate form.

Indicate your best estimate of engineering load in MW/MO. for this proposition

Months	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	1st Year Total	Grand Total
Elec.														
Mech.														
Factory Follow	E													
	M													
TOTAL														

Should agree with Estimated Engr. Sub Total Cost

Est. By—Engineer
App. By—Supervising Engineer
Est. By—Drafting Room
App. By—Chief Draftsman
App. By—UBM. Section
App. By—Sect. Manager

FOR REMARKS SEE OTHER SIDE OF SHEET

Fig. 2—Engineering cost estimates are submitted to the sales department on this Proposition form.

findings of the research group are translated into practical characteristics of a commercial product. Further research may be indicated. Primarily, the development engineers are concerned with producing a device that will perform a certain function in a certain manner, which is the first step in product design.

3. Product design phase—based upon the report and rough operating model, probably furnished by the development engineers, design engineers begin the complicated details of engineering the final product.

Each step in this phase is made to accumulate engineering information necessary to the manufacture of a commercial product. No further research should be required during the design stage. Some further development work may be necessary to establish nominal ratings of mechanical, electrical and other values, and to insure satisfactory performance being maintained over manufacturing tolerance ranges. Product designing includes the adaptation of standard parts in the product, consideration of convenience in servicing, cost of manufacturing, and the production of a model.

While the responsibility for developing a new product is centered within the Engineering Department, other departments should be consulted and kept informed. An experienced product engineer will schedule his progress to provide the proper timing of information required by these departments which represent functions of purchasing, manufacturing, and selling.

Functional Responsibilities of an Engineer

The engineer is responsible for executing that part of a sales plan which will evolve a marketable product usually to sell at a competitive price.

The product should be of good quality and relatively low manufacturing cost. This simple statement involves a long list of considerations. Failure to give due consideration to any one of them will usually reflect adversely on the economy of the company.

ESTIMATES AND SCHEDULES: The engineer's responsibility begins with receipt of a request for a cost estimate and tentative schedule and does not end until the service or product has been accepted by the customer or the sales department.

The cost estimate of a new product may logically be divided into engineering costs, Fig. 2, and manufacturing costs. Engineering costs include engineer's time, laboratory facilities, packing design, drafting, instruction books, traveling expenses, overhead, models of equipment when required, and any other engineering expenses which the peculiarities of the job may incur. Manufacturing cost includes labor, tools, overhead and any other expenses peculiar to manufacturing the product.

A true cost estimate is based upon approved drawings and vendor's prices. It is not issued until final drawings have been signed off. The cost estimate will replace a temporary cost indication if one was issued. The cost estimate is used to price catalogued items and to measure engineering and manufacturing performance.

DEVELOPMENT AND DESIGN: Upon receipt of a sales authorization, an engineering shop order may be issued to accumulate engineering charges. The engineering project may be assigned to an individual engineer or to a group.

Before starting a development or design project, engineers should investigate technical reports on similar products so as to benefit from the experience of others. After development work has progressed far enough to provide sufficient basic information, a model may be produced from rough sketches.

An important part of the product engineer's responsibility is to see that standard parts and practices are designed into new products. The ingenuity and thoroughness with which this is accomplished will be reflected in the overall economy of the project.

MODELS AND TESTS: When the model has been completed, tests will be conducted to see that the model meets the commercial specifications. Some changes may be desirable but only such changes should be made as are necessary to meet the commercial specifica-

tions. New ideas and findings should be recorded in the engineer's notebook and saved for a subsequent design.

If the engineer yields to the impulse to continue development or redevelop the product, he will over-expend his cost estimate and may endanger the overall economy of the project. This impulse is characteristic of a true engineering nature and is hard to curb, but there must be a point at which the design of a product is frozen for manufacture.

When time and funds permit, a second model can be produced. Minor changes can be incorporated, resulting in a model better suited as a guide to the Manufacturing Department in tooling for production.

DESIGN REVIEW AND CONCURRENT FUNCTIONS: When the model has been completed and tested, the product engineer will probably invite representatives from the Manufacturing Department to inspect the model and review the design with the purpose of smoothing out any obstacles which may exist to an economical production program. Design, manufacturing schedule, and selling price will probably be discussed. Concurrent with the manufacturing review of the design other responsibilities should be discharged such as drafting, compiling parts lists, and obtaining patent approval.

The product engineer is usually responsible for the completeness and accuracy of drawings. This includes such factors as dimensions, tolerances, limits and finishes. Usually he is also responsible for seeing that standard parts and practices are called for and will indicate that this has been done when he signs off the drawings. To insure the desired cooperation between engineering and manufacturing, preliminary prints of manufacturing drawings may be submitted to the Manufacturing Department for review before the drawings are signed off. Preliminary prints may also be sent to the Manufacturing Cost Estimating Group to allow that group to proceed in the early accumulation of cost estimates.

The compiling of a parts list is usually a drafting function. Parts lists constitute basic ordering information for the factory, and form important service data in instruction books. When compiling parts lists, recommendations may also be made as to which items should be stocked as spare or replacement parts.

Most of the larger engineering and manufacturing organizations retain one or more patent attorneys. To successfully protect the patent rights of his firm the product engineer should furnish the patent attorneys with written disclosures of any features thought to have patentable possibilities. This is usually done before manufacturing information is released.

RELEASING ENGINEERING INFORMATION: Following the final review of the product design, engineering information will be released to the Manufacturing Department to enable that department to proceed with production. Released information usually consists of:

1. Drawings signed off by the product engineer after checking dimensions, tolerances, limits, finishes, and standardization of parts, materials and methods.

2. Parts lists after checking for quantity, description and recommended spare parts.

3. Engineering notices which contain all pertinent information not otherwise covered by drawings and parts lists.

4. Test and inspection specifications which are important to providing facilities and training personnel for test and inspection in production.

PACKING DESIGN: Frequently packing can be designed around engineering models and thus avoid unnecessary delay in waiting for the first production units.

SALES LITERATURE AND INSTRUCTION BOOKS: It is generally the responsibility of the product engineer to furnish the technical information for this type of literature and to check the copy, before printing, to assure the lucidity and accuracy of technical statements.

ENGINEERS' NOTEBOOKS AND TECHNICAL REPORTS: Engineers' notebooks frequently constitute the basis for patent litigation and the later preparation of technical reports. Technical reports are important mediums for keeping management informed regarding the work that has been done and constitute valuable legal and scientific records for the files.

TECHNICAL PAPERS: Most managements encourage the preparation of technical papers on the ground that they secure wider recognition of the author's achievements and that technical papers provide a high type of publicity for the company.

FACTORY FOLLOW-UP: Throughout the production cycle, factory follow-up is an important product engineer's responsibility. They may be called upon to assist the manufacturing personnel in solving problems on tooling, processing, material substitution or they may have to effect design changes during production.

TESTING PRODUCTION SAMPLES: Time and manufacturing cost may be saved by laboratory testing of pre-production samples and evaluating the samples in the light of the commercial specifications and the engineering model.

ENGINEERING CHANGES: Engineering changes can be the greatest obstacles to satisfactory execution of production

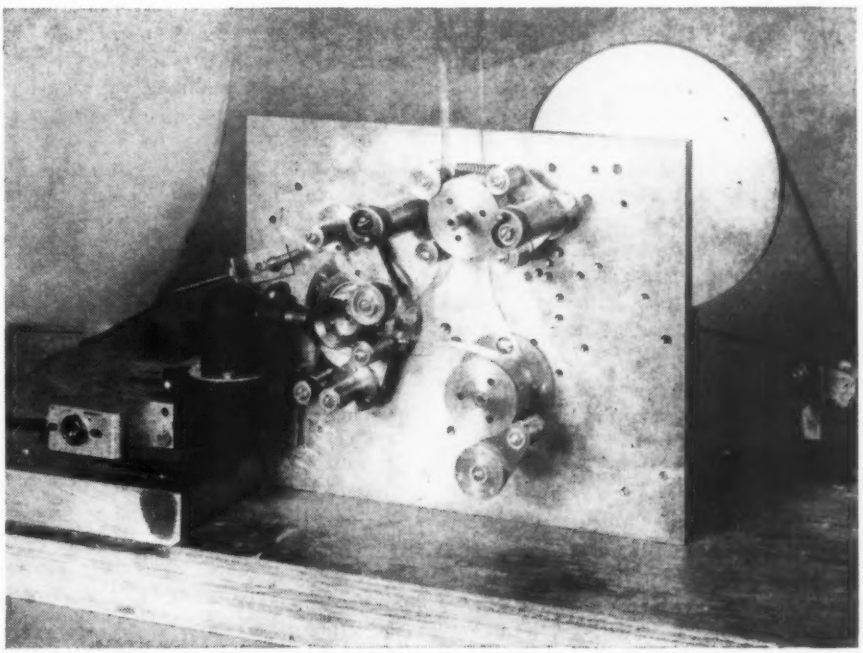


Fig. 3—The "bread board" model is effective for testing basic design.

schedules. For control purposes approval of a responsible person in engineering management is required before such changes can be made.

SPECIALISTS SERVICES: Some organizations retain experts in highly specialized fields. Progressive engineers will avail themselves of their knowledge by consultation.

To insure all major transactions being handled in accordance with predetermined policy, forms are usually prepared and procedures for repetitive operations are written for the guidance of the engineer.

Design Considerations

A product must be designed so that it will fit a specific price bracket. After all other factors of a product specification have been met, the design engineer is usually confronted with the problem of reducing the cost of his product without impairing its efficiency.

Designing for efficiency in a product is a matter of good judgment, right materials, and a knowledge of how to use them. Designing for cost reduction also includes a knowledge of manufacturing methods, cost of labor, cost of processes, cost of materials, availability of materials, and available facilities.

DESIGNING WITH ENGINEERING STANDARD PARTS: Standardization is the design engineer's most effective means of reducing cost and speeding up production. Standards should be established for parts only after a careful consideration.

Standards are sometimes established for parts based on usage. Items that have been used in large quantities are designated as standard items, while items that have been less popular are eliminated, or listed as special. Establishing standards on usage alone has the disadvantage of not being flexible enough to permit of changing the standard as factors affecting its production or procurement change. Once established, such a standard may be perpetuated as long as the demand for it continues, although better materials and cheaper methods may have become available in the meantime.

Standards should be broad enough to serve the widest possible scope of usefulness. They should be firm enough to permit taking advantage of quantity-production savings in costs. They should be flexible enough to take advantage of more suitable materials and improved production methods as they become available. Fig. 4 shows how a particular standardization effort substantially reduced the number of parts used in one department.

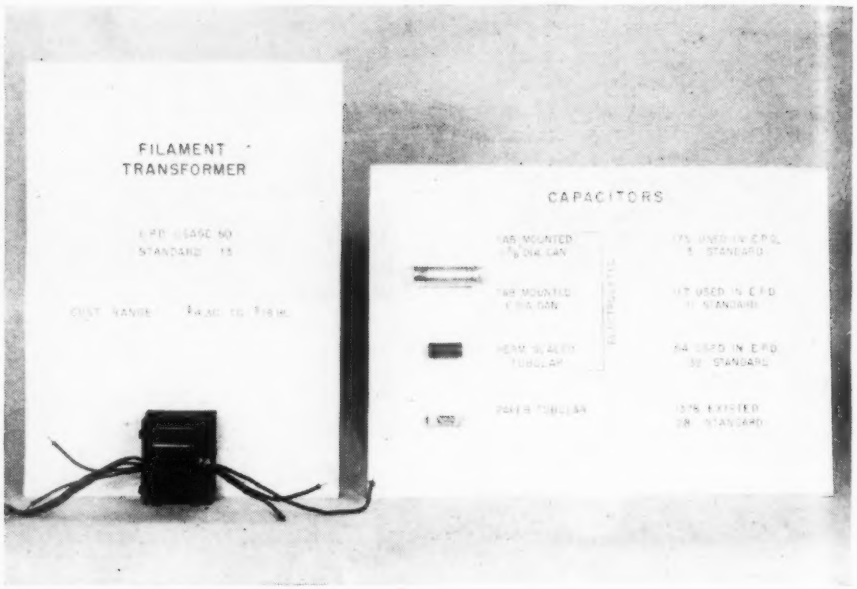


Fig. 4—Standardization in one department reduced the number of transformers and capacitors that had to be kept in stock to a small fraction of the previous total.

CHOOSING FINISHES: Finishes must be selected on both a technical and an economical basis. Occasionally a finish chosen to meet a certain technical requirement proves too expensive for the job. Occasionally the cost of finishing a product may exceed the cost of fabrication.

For sprayed finishes, the cost is in direct ratio to the amount of handling required during finishing. An example would be that of applying the same finish to both sides of a panel as compared to applying a different finish to each side. If different finishes are to be sprayed on, one must be masked from the other before spraying. Unnecessary masking increases labor charges and consequently the cost of the product.

SIMPLICITY IN DESIGN: In designing equipment the engineer determines not only the dimensions and arrangements of parts and assemblies, but he also influences the production methods to be followed, the machinery to be used, and the man power to be employed in manufacturing the product. His ability to simplify the design often results in a higher speed of production and lower tooling requirement. Production economy is improved by the simplification of parts, which results in a less expensive design and greater ease of assembly.

DESIGNING FOR ACCESSIBILITY: Accessibility influences the cost of assembly and of servicing the product after manufacture. Due consideration given to simplification will often also take care of accessibility. The placement of parts in inaccessible locations increases the labor cost in manufacturing. Products are frequently sold to customers on the recommendation of their own engineering or service personnel. Accessibility is an important factor in such recommendations.

NORMALIZING TOLERANCES: If the product demands small tolerances, precision equipment is required. Precision equipment is costly and usually limited in output. Higher skill may be required to operate it, at a higher labor charge. Specifying liberal tolerances has the advantage of lower investment cost in machinery and lower production cost. Watch factory tolerances in radio factory production do not reflect economy in design.

CLIMATIC CONSIDERATIONS: Equipment designed to be used in the tropics ought to employ different components and different design characteristics from equipment to be used in arctic regions.

SERVICE CONSIDERATIONS: The peculiar requirements of the specific service in which the product is to be used must dictate certain design features. A radio receiver designed for home use is not suited to mobile service, or a car radio is not suitable for use in an airplane.

QUANTITY CONSIDERATION: Another factor in designing for cost is the quantity to be manufactured. If the quantity is large, costly tooling with a long life service may be the most economical. If the quantity is small the

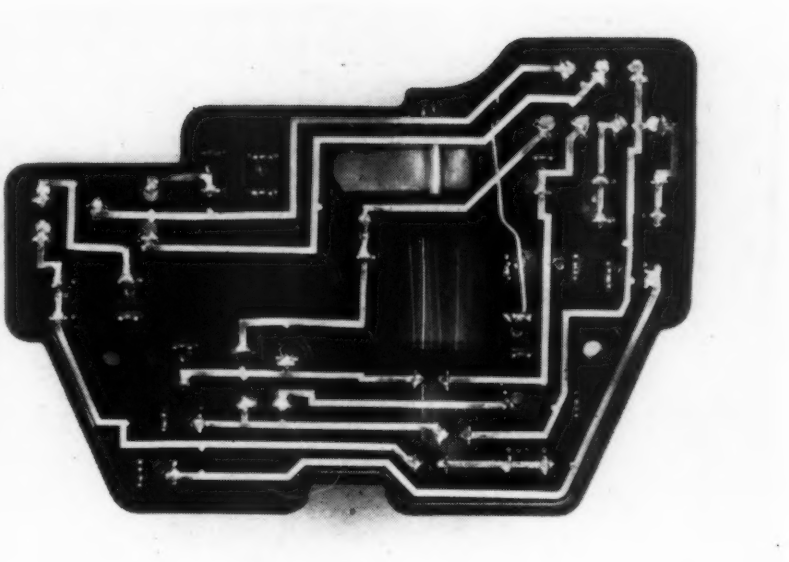


Fig. 5—This cleancut wiring design will save assembly time as well as simplify maintenance. Accessibility under field conditions is often forgotten.

design may have to be accommodated to less expensive production methods.

QUALITY: The quality of a product is in a large measure a reflection of the individuality of the person who designed it. Designing for quality calls for ingenuity and good judgment.

EFFICIENCY: The efficiency with which an engineer performs his work, as well as the efficiency with which a product performs its function, largely reflects the extent to which an engineer applies his own experience and the experience of others.

SAFETY CONSIDERATIONS: There are a number of safety factors which must be considered: (1) Does the design call for the use of materials or processes injurious to the health of those manufacturing the product, or dangerous to the equipment used in its manufacture? If so, can other materials or processes be substituted? If not, proper precautions must be taken before manufacturing starts. (2) Does the equipment afford any safety hazard to those operating it? Safeguards may be required or warning labels may be needed. (3) Is the equipment safe to service? Are sufficient interlocks or other protective devices employed?

PROCESSES: An engineer should not suggest an unfamiliar manufacturing process without first investigating it. Good engineering requires close cooperation with those who determine the processes.

TOOLS: Tooling can be one of the most costly items in producing a new product. The quantity to be manufactured and physical design characteristics are prime factors in determining the tools to be used. A preliminary consultation with those who determine the process and those who design the tools may mean the difference between financial failure and success of the project.

SAFEGUARDING PARTS DURING MANUFACTURE: Parts should be designed so that they will not be damaged in normal factory handling. Welded studs on panels or other protrusions may mar the finish on adjacent panels during handling. If parts cannot be designed to avoid damage in handling, special handling instructions will be necessary.

INSPECTION: Cases have been cited in which the cost of inspecting a part was more than the cost of producing it. This can be avoided by giving design consideration to production and inspection methods to be employed.

STYLING: The design engineer is responsible for providing a product acceptable to the customer. In hand with utility value, the customer demands eye appeal. Here the engineer should have available the consultation services of a specialist in styling. Acceptance of styling is usually the prerogative of the Sales Department.

From the preceding discussion it must be fairly obvious that the creative cycle of a new product is dependent upon a vast amount of good judgment, a great deal of paper work, and numerous reference books; that the design engineer is invested with great responsibility; and that there is adequate information for his guidance, if he will use it.

Engineers are urged to make use of the check list in Table I. The practice of checking off items as they are completed will avoid forgotten items.

Table 1—Factors to Be Considered in Evolving a New Product

1. Development
   - Demonstrates the application of a principle to a product
2. Design has been checked for:
   - Quantity
   - Cost
   - Type of service
   - Climatic conditions
   - Standards
   - Simplicity
   - Accessibility
   - Quality
   - Efficiency
   - Safety
   - Normalizing tolerances
   - Processes
   - Tools
   - Safeguarding parts in manufacturing
   - Inspection
   - Finishes
   - Styling
3. Model has been completed, as well as:
   - Type tests
   - Patent applications
   - Management approval
   - Underwriters' approval
4. Drafting has been checked for:
   - Dimensions
   - Tolerances
   - Limits
   - Finishes
   - Standards
   - Processes
5. Pertinent information has been released for:
   - Manufacturing
   - Test specifications
   - Packing design
   - Technical reports
   - Instruction books
   - Sales literature
   - Technical papers

* * * *

THE FIRST ELECTRO-MAGNET was made by the Englishman, Sturgeon, in 1825. It consisted of a small iron bar bent into horseshoe form with 18 turns of bare copper wire wound loosely around it. In 1828, Joseph Henry, an American, exhibited the first of his revolutionary electro-magnet designs. The copper wires of this electro-magnet were silk covered. By insulating the wire instead of the iron bar, a large number of turns could be formed into a compact coil with great lifting power. Little change has been introduced into Henry's basic electro-magnet design.

Fig. 1—Knowing how shock or vibration mounts work is a prime necessity in designing mounting systems for equipment.

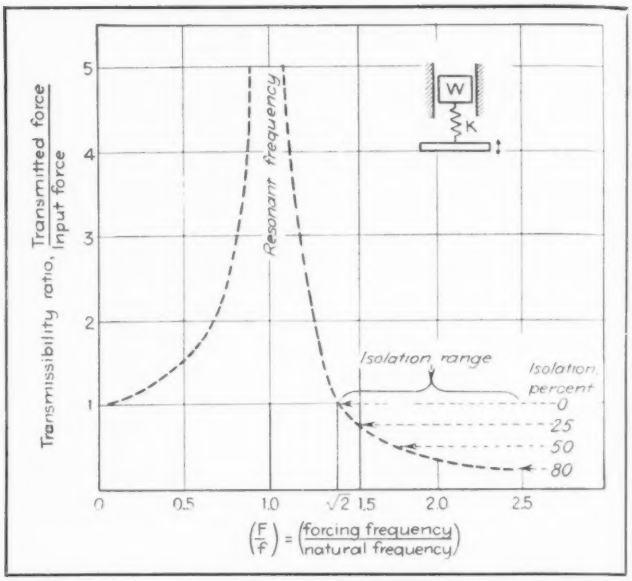


Fig. 2—Transmissibility curve typical of linear, single-degree-of-freedom, undamped systems. Isolation range is used for design.

Vibration Isolation and Shock

PROPERLY DESIGNED vibration and shock mounting systems perform a vital job by protecting complicated, expensive, or delicate electric and mechanical equipment. Yet it has been the experience of the author that of all equipment submitted for shock and vibration contract approval tests, ninety percent are equipped with mounting systems that, at best give only partial protection, and at worst intensify the effects of the vibration or shock.

The point of departure, then, in discussing the vibration and shock mounting problem is to point out that commercial mounts are designed to include specific characteristics that protect equipment from specific kinds of shock or vibration. The effect of these characteristics must be recognized when mounts are incorporated into an individual mounting system.

A typical mounting problem, then, comprises: (1) Determination of shock or vibration field conditions; (2) selection or design of mounts with the proper elastic characteristics; and (3) proper location of these on the equipment.

Methods for determining vibration and shock field conditions will not be discussed here, though these data are used in setting up the conditions of the problem. Generally, specifications ordinarily supply this information and are aimed at paralleling field conditions of some limited intensity, well below what has been found to be the peak or maximum. These specifications allow for a compromise between size, weight, and economic factors on the one hand, and protection and operating efficiency on the other.

To design a vibration isolation mount system, it is necessary to recognize that exciting vibratory forces may be continuous with constant frequency and amplitude or that these parameters may vary. Similarly, in a shock mount system, shock forces may be intermittent with high or low frequency components, or both, and may be accompanied by large displacements.

More important than finite values for vibration and shock load conditions is an understanding of the physical nature of vibration or shock loads, and the change in the response to these provided by the mounting system used.

VIBRATION

Protection from vibration is simply a matter of locating resonant frequencies below the frequency of exciting vibration. Resonant frequency or natural frequency is a characteristic of all physical bodies just as is length, color, texture, or weight.

The following experiment is suggested to demonstrate the meaning of resonance and natural frequency. Take a piece of spring steel or a flexible scale and extend it in the form of a cantilever over the edge of a desk; hold one end firmly against the edge of a desk and pluck the free end. The cantilever vibrates at a particular frequency, its natural or resonant frequency. If the cantilever length is increased, or a weight is attached to its free end and it is plucked again, the frequency is lower than before. If the free length is shortened, the resonant or natural frequency is raised. This responding frequency is so uniform at any one length of the cantilever that commercial tachometers and various forms of frequency meters have been made incorporating this principle.

Take the same cantilever with a large weight on the end, that is, one of low natural frequency, and holding the unweighed end in your hand, move it up and down very slowly. Your hand and the weight will move together. Now, gradually increase the exciting frequency (the up and down motion of your hand) and note that the weight and your hand do not move up and down together. There is a phase difference in their relative motions; in fact, the excursion (total travel) of the weight will be larger than that of your hand and will increase as the frequency of vibration increases, up to the natural or resonant frequency. At this point, the relation between the excursion of your hand and the excursion of the weight will be a maximum; this relation is called the transmissibility.

As you further increase the exciting frequency, the excursion of the weight

• The opinions expressed in this article are those of the author and are not to be construed as official opinions of the United States Navy Department.

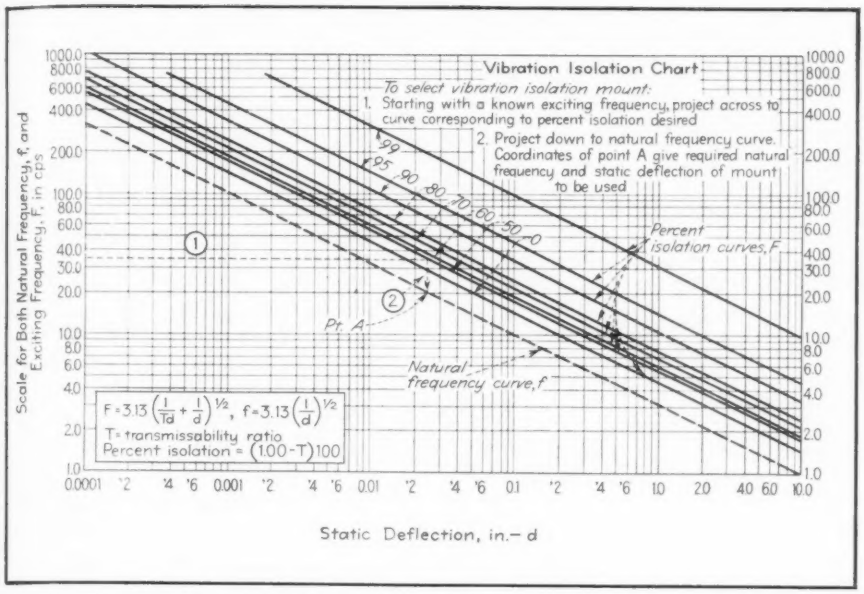

Vibration Isolation Chart
To select vibration isolation mount:
1. Starting with a known exciting frequency, project across to curve corresponding to percent isolation desired
2. Project down to natural frequency curve. Coordinates of point A give required natural frequency and static deflection of mount to be used
Percent isolation curves, F
Natural frequency curve, f
Pt. A
Scale for Both Natural Frequency, f, and Exciting Frequency, F, in cps
Static Deflection, in.– d
F = 3.13 (1/Td + 1/d)^½, f = 3.13 (1/d)^½
T = transmissibility ratio
Percent isolation = (100-T)100

Fig. 3—Chart for determining characteristics of undamped mounts required to provide protection from forcing vibration. Chart applies to most commercial vibration mounts.

Mounting

Carl J. Bastien*
Naval Research Laboratory

or the transmissibility ratio decreases. The decrease continues until the excursion of the weight becomes less than that of your hand. The weight is then in the isolation range of frequencies; it is being protected from the vibration of your hand. Shown in Fig. 2 is a transmissibility curve typical of linear, single-degree-of-freedom, undamped systems. The equation from which Fig. 2 was plotted is as follows:

$$T.R. = \frac{1}{1 - \left(\frac{F}{f}\right)^2} \qquad (1)$$

where

$T.R.$ = Transmissibility ratio, $\frac{\text{weight excursion}}{\text{exciting excursion}}$

F = frequency of exciting vibration, cps

f = natural frequency of system, cps

This equation does not give positive values after resonance is passed; but since only absolute values are of interest, the transmissibility curve above the resonant frequency is shown plotted in the first quadrant.

The transmissibility at resonance is a measure of the damping or hysteresis present in the mounting material and is important if the installation must operate through the resonant frequency. However, if resonance is not excited in an installation, damping is a disadvantage, for it increases the transmissibility in the isolation range.

A point to be noted from the foregoing cantilever experiment is that as the weight is increased or as the effective length is increased, the natural frequency is reduced. Or, expressed in another way, as the initial static deflection of the beam is increased, natural frequency decreases. This can be expressed mathematically by the following equation:

$$f = 3.13\sqrt{\frac{1}{d}} \qquad (2)$$

in which

d = static deflection, in.

This equation is plotted as the zero percent isolation curve in Fig. 3. If actual measurements for static deflection of the free end of the steel cantilever are made, the resulting natural frequencies will be found to agree closely with the values given by the curve.

Eq (2) applies, to a reasonable extent, to most common resilient mounting materials used, such as rubber and steel springs in which the restoring force varies directly with displacement, and probably applies, to a lesser degree, to cork and felt.

The action of the cantilever beam discussed here is analogous to the action of commercial mounts. (See schematic in Fig. 2). The weight at the end of the cantilever is the equipment weight, W, supported by the spring, K. Cantilever static deflection, when loaded by W, corresponds to spring deflection, and cantilever stiffness corresponds to spring stiffness. Hence Eqs (1) and (2) are generally applicable to commercial mounting systems.

Shock

To solve a particular shock mounting problem three conditions must be known:

1. Field conditions from which protection is desired.
2. Space available around the equipment for mount installation and shock motion clearance.
3. Vibration excitation conditions existing at the proposed installation location.

Shock mount problems are more difficult to solve than vibration isolation problems. But the solutions are surprisingly analogous.

Shock mounts are ordinarily designed to protect equipment from the particular type of shock involved. There are many distinct kinds of shock; the damage caused by any one of them to a structure or one of its elements is as much a function of the shock pulse and its parameters as it is of the structure shocked. These defining parameters are frequency, amplitude, number of cycles, and phase relationship.

Damage to any structure due to steady-state vibration is made enormously more probable by the presence of a resonant condition; that is, when the natural frequency of the structure, or one of its elements, coincides with the exciting vibrational frequency. A condition analogous to resonance can exist in the case of shock; if the natural frequency of a structure, or a component, is close to the effective, or a predominant, frequency of the shock pulse or wave component, a condition occurs similar to resonance in steady-state vibration. As a result the stress in the particular member due to shock may become many times that in adjacent members having different natural frequencies.

The analogy can be carried further to the interesting case in which a condition similar to isolation in steady-state vibration is found in shock loading. This occurs when the duration of the shock pulse is much shorter than half the natural period of the structural element.

To amplify this important point, the unit of gravitational acceleration, g, may be mentioned. In the usual solution of impact loading problems, a structure subjected to an impact load, accelerated at x g's will be stressed x times the stress of one g. But this measure of shock or impact corresponds to the amplitude parameter only, and, as in vibration, amplitude is not a true measure of stress in the

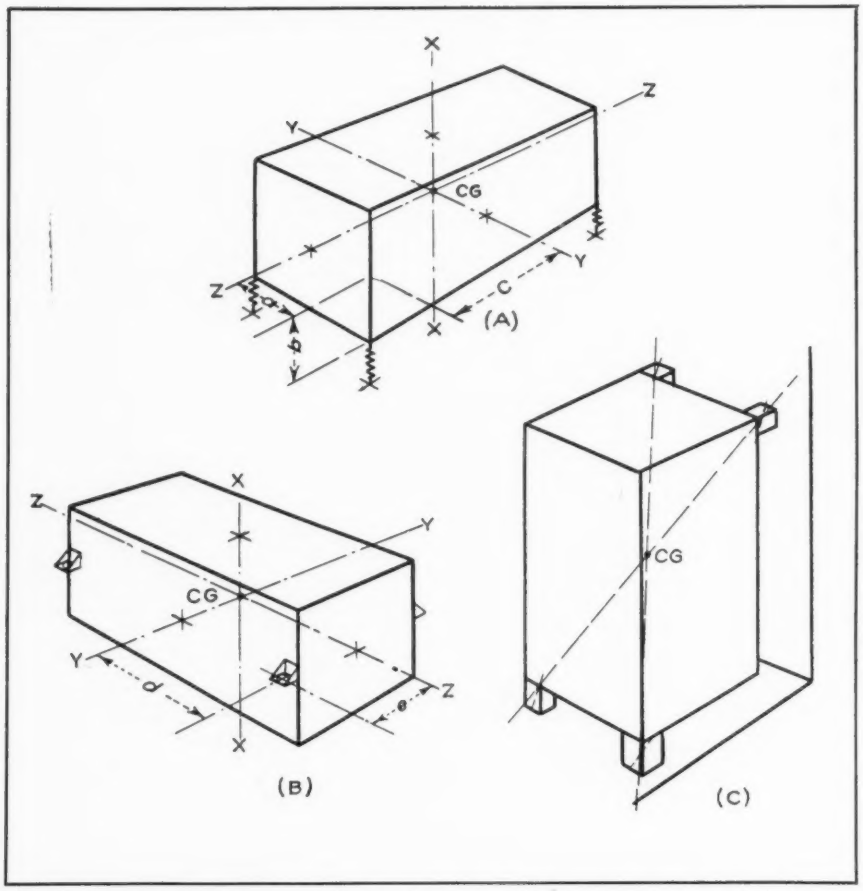


Fig. 4—Arrangements for supporting equipment on vibration isolators or shock mounts.

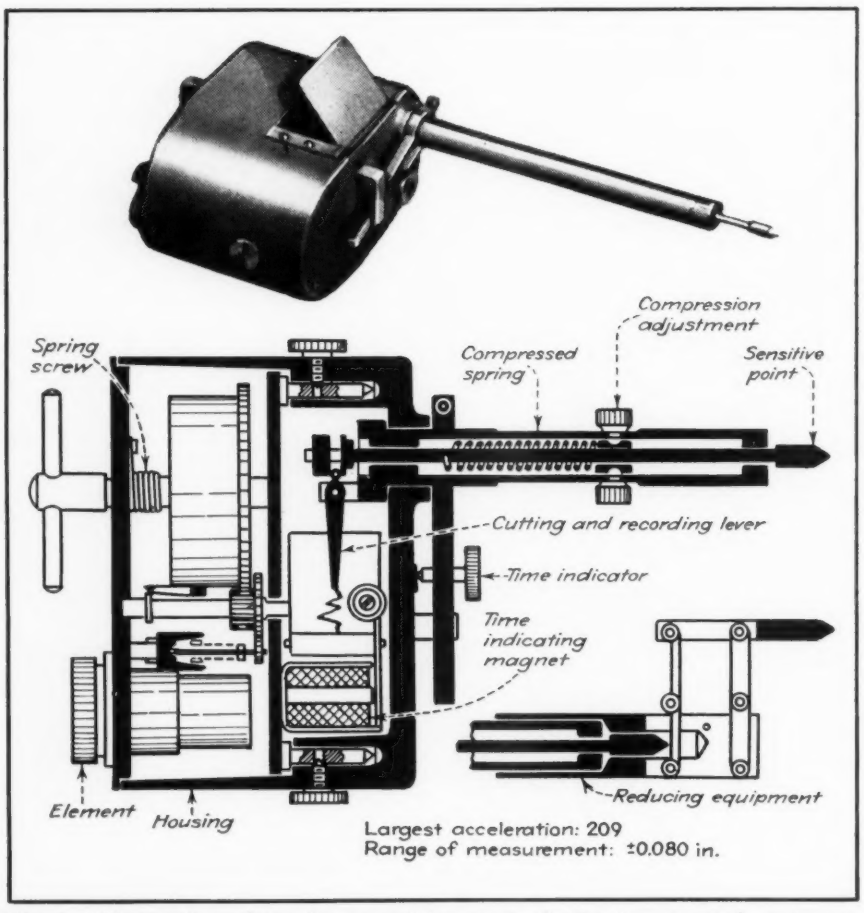


Fig. 5—Vibrograph to determine natural frequency of vibrating mounted equipment.

loaded structure, nor is it proportional to resulting damage.

As an example consider the simple system shown in Fig. 2, and assume that it has a vertical natural frequency of 20 cps. It is shocked with a single sinusoidal pulse of 1000 cps frequency and 1000 *g* peak. The resulting deflection of the spring would probably correspond to less than a hundred times the weight, i.e., the base of the weight would experience an acceleration of less than 100 *g*. On the other hand, if the same system is shocked by a load having a single sinusoidal pulse of 30 cps duration and 1000 *g* peak, the resulting deflection of the spring will be approximately 1700 *W* or 1700 *g*.

The complete solution to an individual shock mounting problem in a complicated structure, like electronic equipment, is practically impossible theoretically, and without question that approach is uneconomical.

The solution, in the design of electronic gear, is not simply one of "increasing sections," for that can cause trouble just as quickly and easily as if the section is too light.

The approach to the problem by the larger and better equipped companies is one of a combination of theory and experiment. There are many fundamental design criteria that are of help; a number of publications have been written concerning the theories involved and more complete information is in the process of publication at the present time of this writing. The method involves making the best possible use of the theoretical material at hand and then testing the equipment, with subsequent redesign if necessary.

In conjunction with the problem of shock resonance, it must be remembered that common shock phenomena are not pure sine pulses of a single predominant frequency but are usually made up of many frequencies.

Typical Mounting Problem

Consider a typical mounting problem—mounting a piece of equipment as shown in Fig. 4, in which the center of gravity is at the geometric center of the shape. If the mounts are placed on the bottom, as shown in Fig. 4 (A), the body may have as many as six different resonant frequencies as follows: (1) Vertical: translational along the *X* axis; (2) Rotational about the vertical axis; (3) "Low rocking" in which the box rocks in a vertical plane parallel to the *X-Z* plane and about a center below the center of gravity; (4) "High rocking" in which the box rocks about a center located above the

center of gravity such that the motion takes place in a plane parallel to the X-Z plane; (5) and (6) similar to (3) and (4) except that the motion takes place in a plane parallel to the X-Y plane.

The parameters, which determine the different resonances in the problem outlined, are the distances *a*, *b*, and *c*, the horizontal and vertical stiffnesses of the mounts, and the moments of inertia of the box about the *X*, *Y* and *Z* axes. If the mounts are equally stiff in the horizontal and vertical directions, and are placed as shown in Fig. 4(B) or 4(C), so that the center of gravity of the box lies in the same plane as the four mounts, and the mounts are installed in pairs equidistant from but on opposite sides of the center of gravity, the resonances are much easier to control. The resonances are then said to be decoupled; an excitation of one will not cause a vibration in another mode. The resonances then reduce to three translational, one parallel to each of the three major axes, and three rotational, one rotational about each of the major axes. The possibility of excitation of the rotational resonances is small in ordinary industrial installations; so, of the six resonances originally present, only three are active or likely to be troublesome. Further, if the mounts are located as shown in Fig. 4(B) distance *d* be made equal to the radius of gyration of the body about the Y axis, and distance *e* equal to the radius of gyration of the body about the *Z* axis, the six resonances will be equal. In many cases this is an unnecessary refinement for ordinary mounting problems.

Generally, the problem of designing a satisfactory mounting system for a piece of equipment already constructed will be one of making a fair estimate and then proving the matter by experiments.

For equipment in which the center of gravity is not at the geometrical center of the box, it is sometimes desirable to provide mounts of different stiffness for the different corners of the equipment so that the static deflections are equal for all the mounts. However, this may cause trouble on the assembly line, for mounts look the same and may be misplaced on the equipment. Rather than providing different mounts for the different corners, and symmetrically locating the mounts about the geometrical center of equipment, it is better to locate equal stiffness mounts symmetrically about the center of gravity of the equipment.

A simple and reasonably accurate method of estimating vertical resonant frequency for small amplitude vibrations, if mounts are available, is to get a load-deflection curve of the mounts and use the data to solve Eq (3), which is a variation of Eq (2).

$$f = \frac{1}{2\pi}\sqrt{\frac{Kg}{w}} \qquad (3)$$

where

K = average slope of the vertical load-deflection curve of the mount at the load w, lb per in.

w = ¼ of the weight, in pounds, of the box if four mounts are to be used located symmetrically about the center of gravity.

g = acceleration due to gravity, 386 in per sec²

f = vertical natural frequency, cps

Experimentally proving a mounting can be done a number of ways. The best is to install it and try it out in actual use. If field conditions are known, the next best is to place the mounted equipment on a vibration machine and determine resonant frequencies in the vertical and high-and-low-rocking resonant frequencies about the two principal horizontal axes.

Another method of determining low-rocking and vertical resonant frequencies, which is applicable if the equipment is small, makes use of the fact that when struck properly, resilient members vibrate at their natural frequencies. By striking the equipment with the hand, the resulting frequency of vibration can be measured with a stroboscope or a vibrograph. (A vibrograph is a mechanical instrument which has a spring-loaded probe that contacts the vibrating equipment. The probe is connected through a lever system to a scribe which follows the motion of the equipment, marking this motion on a tape upon which time intervals are marked simultaneously. By counting the number of vibrations in a given time interval, the natural frequency can be found.) Fig. 5 shows an assembly and section drawing of one type of vibrograph.

In a later article, shock mount materials will be discussed and data given for a number of commercial shock and vibration mounts.

Advanced Technical Training in Germany Not Controlled

ADVANCED TECHNICAL TRAINING in Germany is available only to those who can afford it, according to an Office of Technical Services report prepared by Dr. E. G. Williamson, dean of students, University of Minnesota. With few exceptions, "laissez-faire" methods govern admission of students to advanced training in technical high schools and universities.

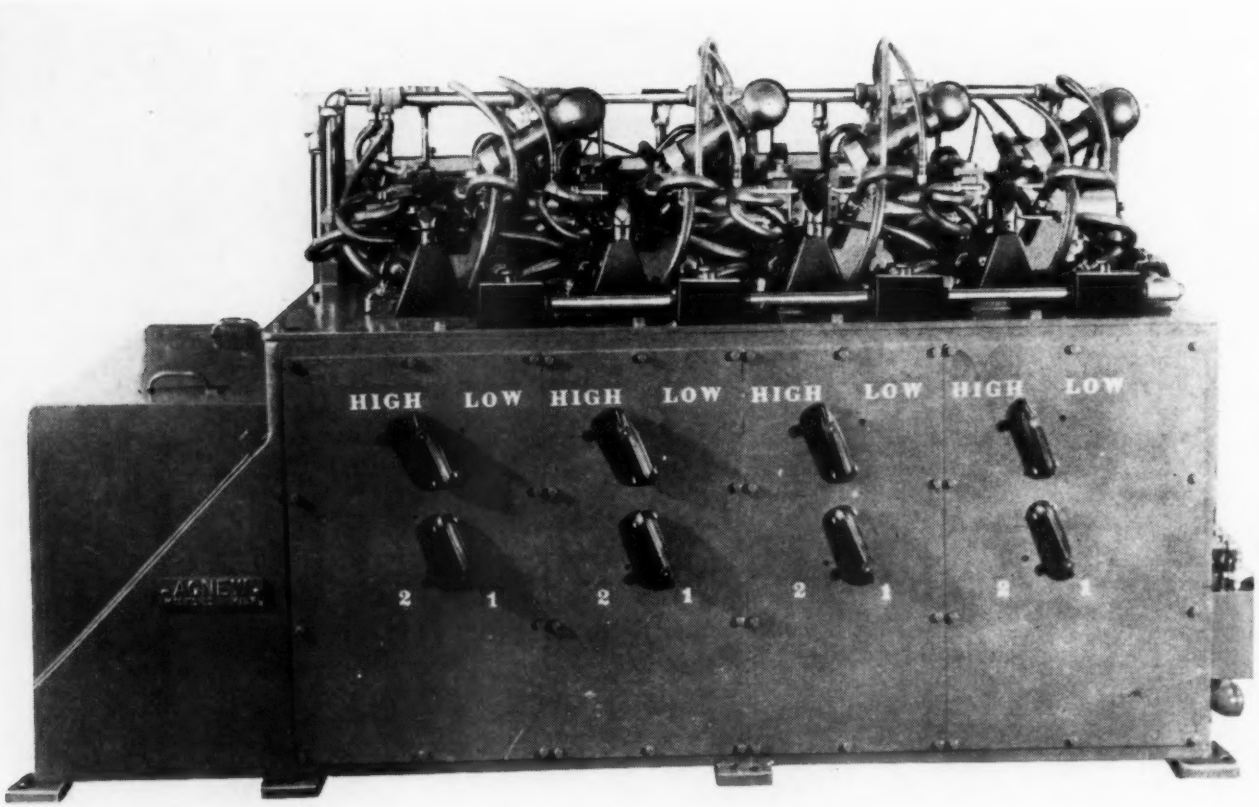
After investigating 30 German industrial and educational officials it was determined that the German educational system has produced a large number of highly trained technical men, but has failed to provide equal opportunity for all social and economic levels of the population.

A quota system for admitting students to specialized training courses, such as in law and medicine, further hampers development of effective selection, counseling, and training methods. The quota for medical students at Berlin University is proportional to the number of available physicians in Germany and bears no relation to the number of high aptitude students who apply for admission.

On lower educational levels, the German government has made available nation-wide vocational counseling and testing programs for sub-professional workers and skilled tradesmen. In like manner, large German industries have continued to expand and strengthen their testing programs for selecting, classifying and assigning men and women to skilled factory jobs.

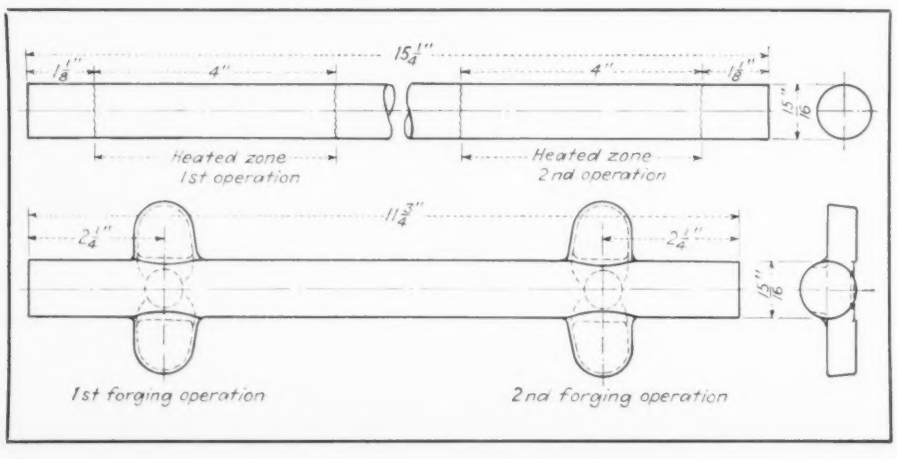
At the very time, during the recent war, that the German nation was utilizing every known scientific device for further exploitation and utilization of its natural and physical resources, the nation's agencies for producing technically trained manpower continued to use laissez faire methods for identifying individual youths. In the lower social groups, the Nazi regime before the war intensified the traditional mass pressure of service to the state as opposed to individualized self-development. This pressure was a form of compulsory occupational distribution, especially below the professional and technical occupational levels.

Mimeographed copies of the report (PB-85192; "Counseling and Selecting Personnel with High Aptitude for Technical Training) cost 75 cents. Orders should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order payable to the Treasurer of the United States.

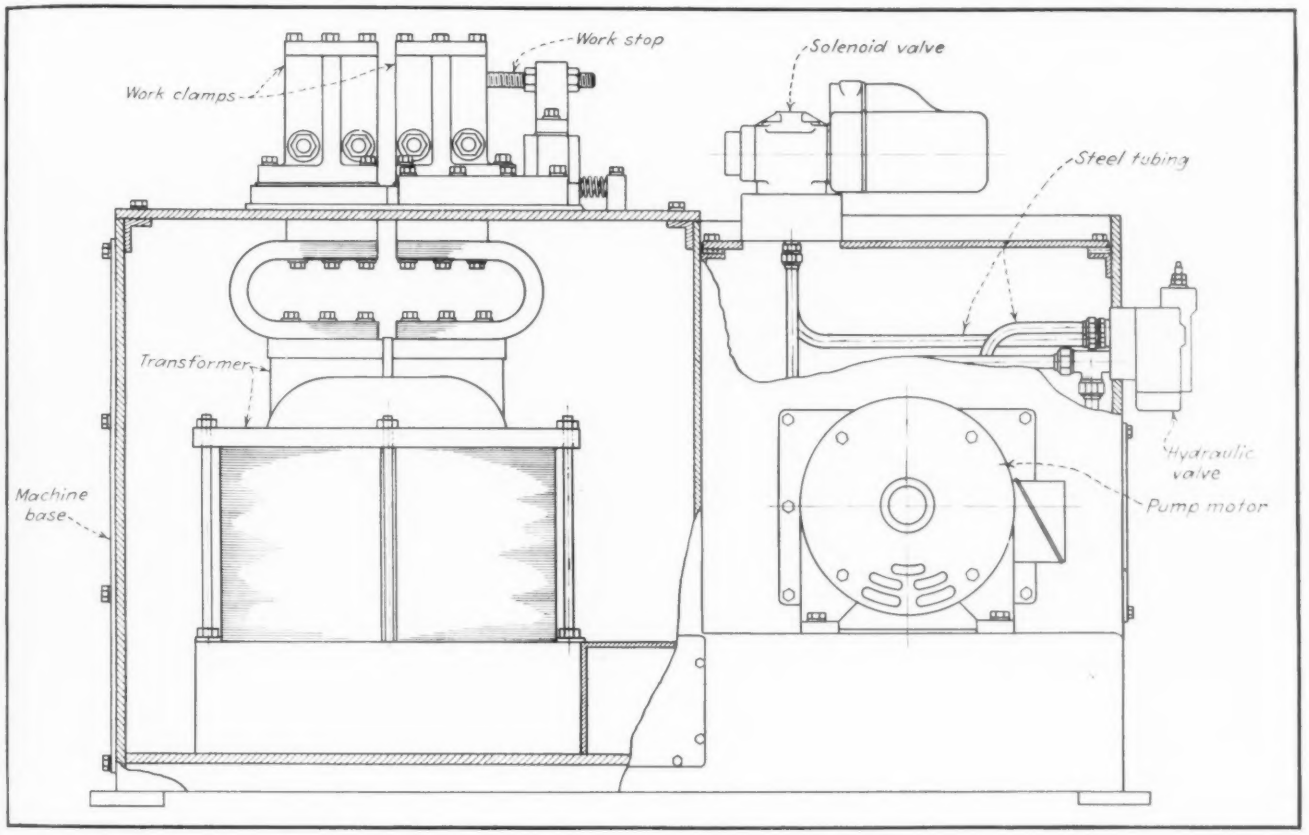


Four Station Electric Resistance Heater

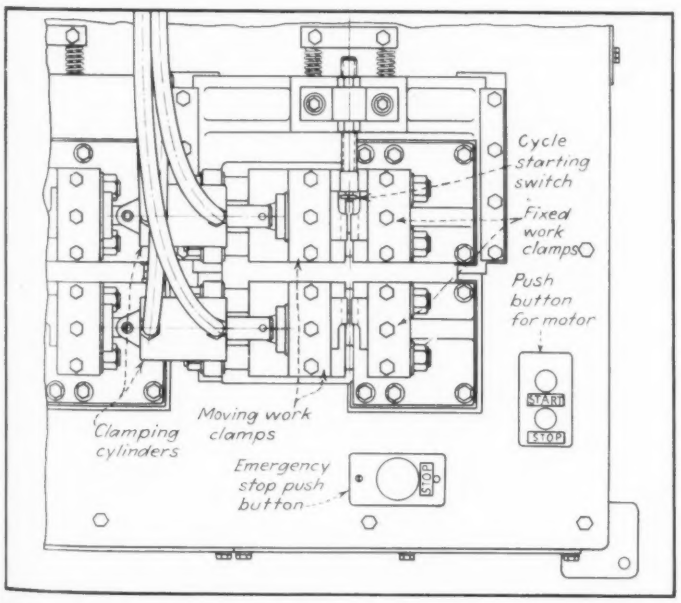
The heating of forging blanks by the electrical resistance method is accomplished by this compact four station machine. The forging blank is gripped between electrodes and low voltage, high amperage current passed through the work, causing it to heat because of its resistance properties. The current is supplied by a transformer built into the machine. Transformer is connected to a standard power supply line. In this type of heating no power is consumed unless the work is being heated. The parts are heated to 2300F in 12 seconds. For this operation 800 lb of steel was heated per hour at a power consumption of 1 kwhr for each 7.4 lb of steel. The machine is 90 in. long, 58 in. wide, 54 in. high and weighs 8,000 pounds. It is built for many applications by the Agnew Electric Co., Milford, Mich.



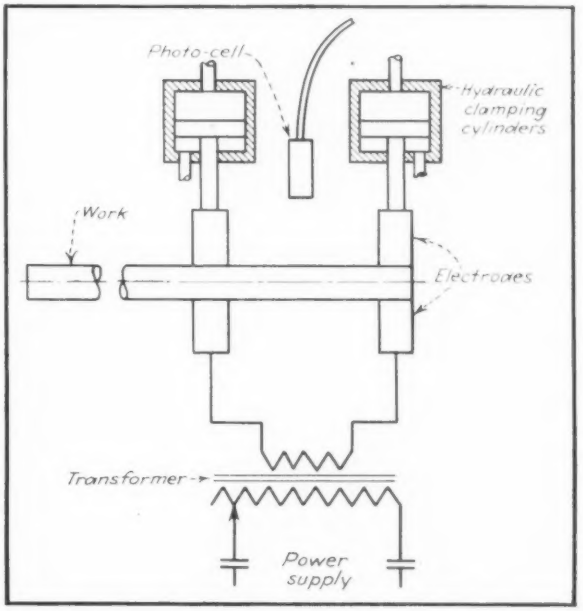
TYPICAL APPLICATION of resistance heating is this automotive knee action lower control arm shaft. It is made from a 15/16 in. round by 15¼ in. long SAE 1024 steel blank. A section approximately 4 in. long has to be heated to 2300 F for the forging operation. The part is then transferred to an upsetter and forged as shown. The other end is then heated and forged in the same manner. These pieces can be heated at the rate of more than 1000 pieces per hour with one operator by the machine described here.



MACHINE CROSS-SECTION shows the bolted frame construction. Transformers, located under the work table, are water cooled. They provide low voltage, high amperage current for heating the work. Operating from a standard frequency single phase power supply circuit, they have inorganic insulation and are rated at 75 kva each. External 3 hp motor drives hydraulic pump inside the tank through a flexible coupling connection.

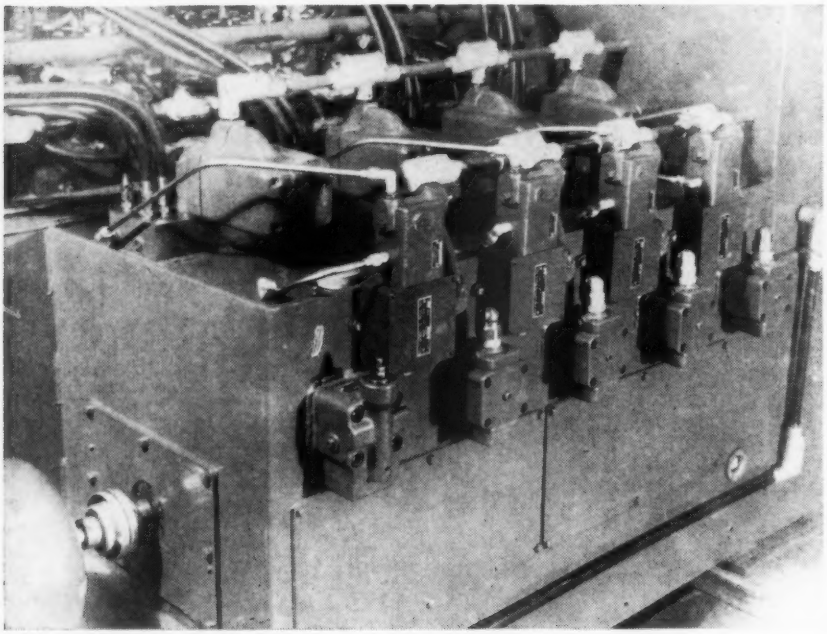


PARTIAL TOP VIEW shows fourth station of the machine. Work is clamped by double acting hydraulic cylinders. Removable water cooled electrodes have alloy inserts brazed in place. One half of the clamping unit is stationary and the other half is mounted on a slide to permit expansion of the work. Flexible secondary leads connect clamping mechanisms and transformer.

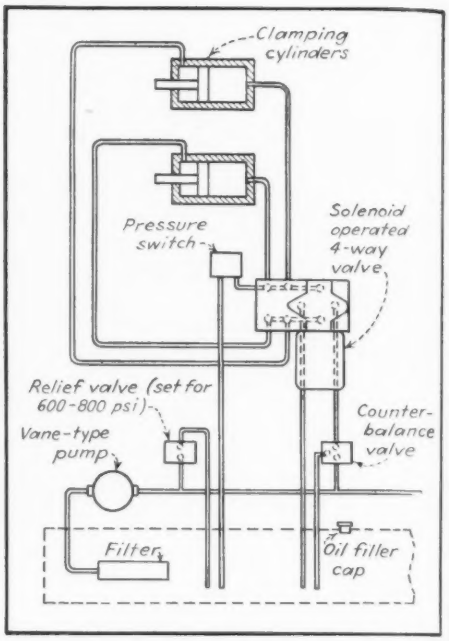


BASIC METHOD is shown. Any part that can be gripped between electrodes and has a uniform section can be heated by this method. Certain sections that are to be forged or bent can be heated, leaving the rest of the part cool. Because of rapid heating, minimum scaling occurs. (*continued on next page*)

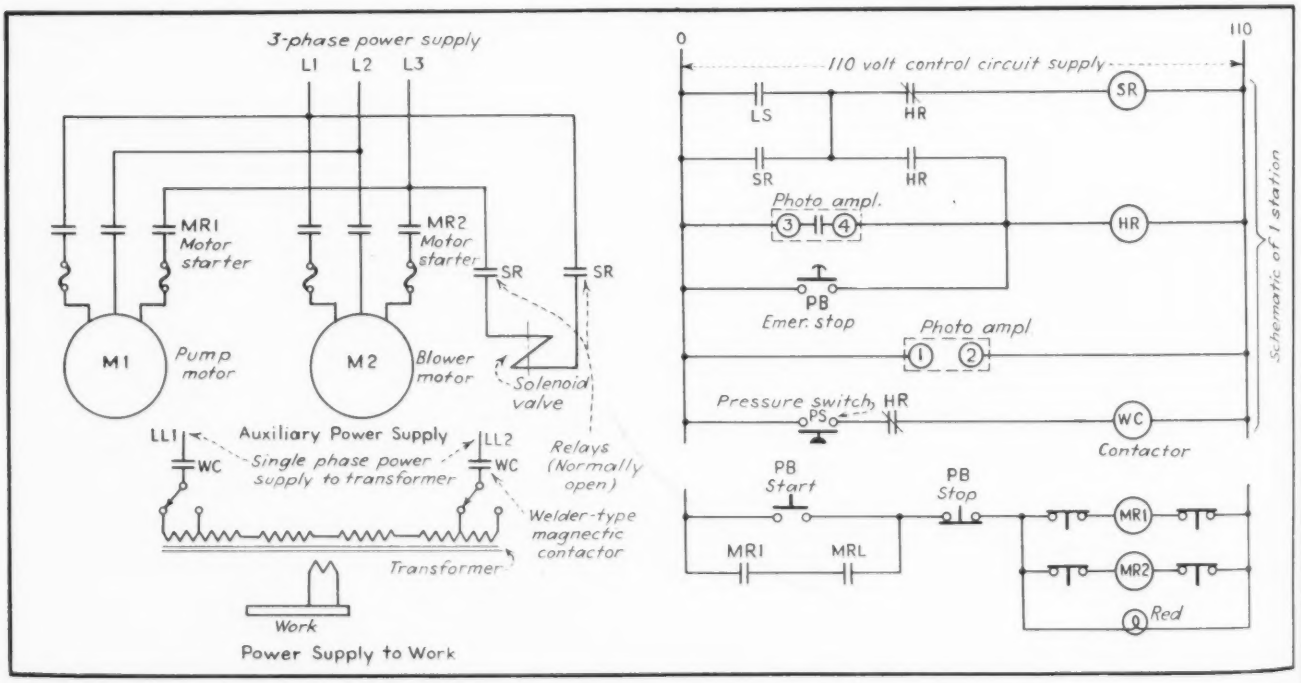
Resistance Heating Machine (continued)



HYDRAULIC VALVES are gasket mounted on the outside of the machine. They are internally connected with steel tubing located inside the hydraulic oil tank. By using gasket mounted valves, they can be removed without disturbing the piping. Any leakage that might occur in the hydraulic lines goes into the tank. Solenoid operated valves are the spring offset type.



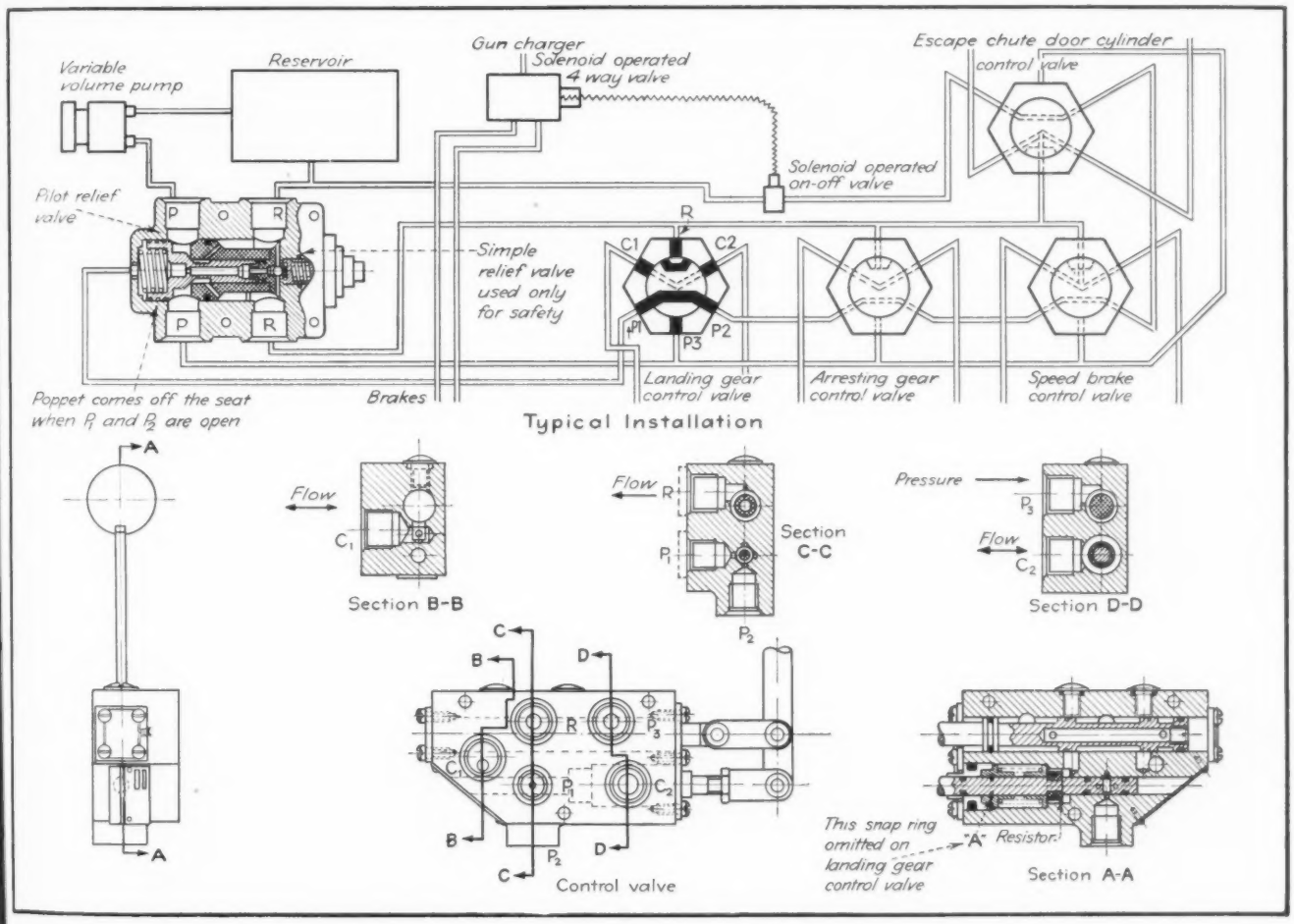
HYDRAULIC CIRCUIT for one station is shown. Cylinders clamp work when solenoid is energized. Pressure build-up in cylinder line operates pressure switch, which starts the heating cycle.



WIRING DIAGRAM for machine. When work touches stop, switch LS closes and energizes relay SR to start cycle. When SR is energized it operates the solenoid valve, which permits hydraulic pressure to operate work clamps. When work is clamped, the pressure build-up operates switch PS. Switch PS being closed, causes contactor WC to energize transformer and start heating cycle. When work temperature reaches setting of photo-amplifier, normally open contact between 3 and 4 will close, energizing HR. When HR is energized the supply to contact WC through its normally closed contact between PS and WC is broken. Thus the heating cycle is stopped. Also when HR is energized by the photo-amplifier, the supply to the SR relay will be broken by the normally closed HR contact in this circuit, and the work is unclamped. Emergency stop energizes HR relay, turning off heat and unclamping work.

High Pressure Hydraulic Control System

This aircraft control system, known as the "Non-pressurized in-flight system," has relatively no existing pressure during the flight of an airplane. Operating pressure of 3000 psi is present only during the take-off and landing intervals when the landing gear is in the down position. This design avoids the fire hazard that can occur in a high pressure system when the fluid leaks out and atomizes. The system is similar to the common open-center type except that all elements can be operated simultaneously during any part of the flight interval. All control valves are similar except for the landing gear control valve, which has a snap ring omitted. Pressure is maintained in the system when the landing gear is down, thus providing pressure for brakes, wing flaps and arresting gear, and for ground servicing operations. The system and its components are manufactured by Air Associates, Inc., Teterboro, N. J.



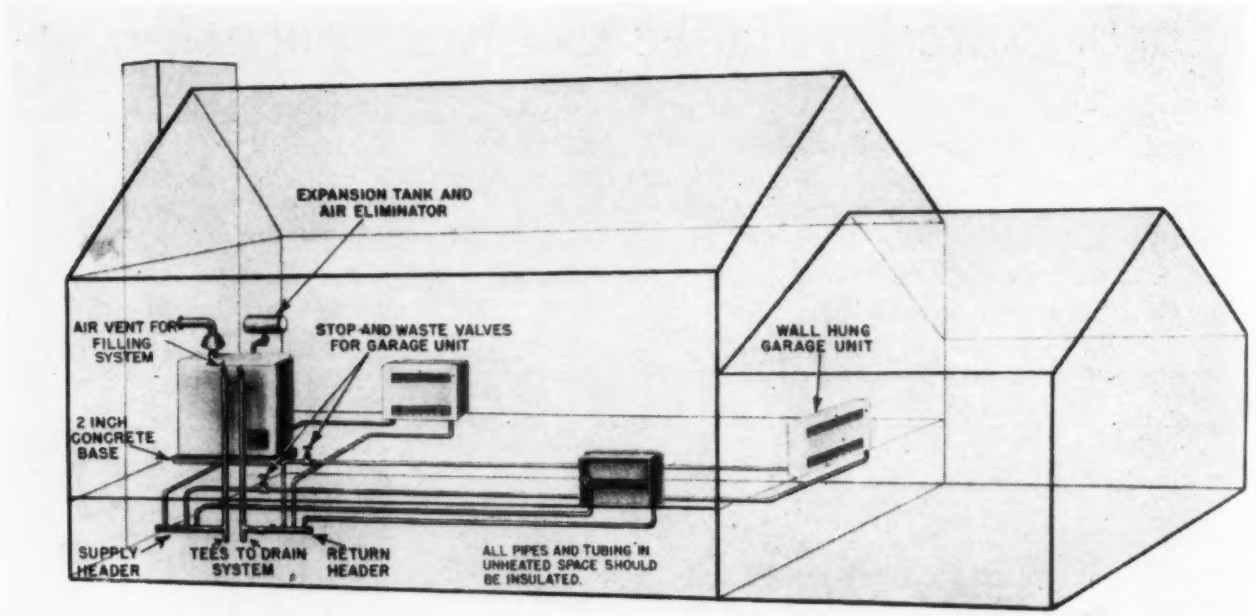
CONTROL VALVE SECTION is a four-way control valve. Pressure chamber is split into two chambers, one at each end of the plunger. When handle is operated in one direction, flow is directed through one of the "C" ports; and when operated in the opposite direction, flow is directed out the other "C" port.

Lower part of valve operates a plunger that opens and closes a passage between the P1 port and the P2 port. This is done during the same operation which actuates the operating handle. Opening and closing of the passage between the P1 port and P2 port of any or all of the valves in the system, raises and lowers the pressure in the system. When P1 and P2 ports are in open to each other, the system is charged to full 3000 psi operating pressure.

Lower plunger is spring loaded so that a centering load exists at all times, tending to return the plunger to neutral. Part of the plunger is exposed to the flow of fluid going in and out of the C2 ports. Hydraulic "resistor" attached to this plunger is sensitive to flow, so that a pressure drop is created during an interval of flow. When there is no flow, the pressures on each side of the "resistor" are equal. Centering spring load is then sufficient to return the plunger to neutral.

After the handle has been actuated, the hand is removed. The handle remains in its extreme position until the controlled element has completed its cycle. After the cycle is completed, handle moves a fraction of the full distance toward neutral.

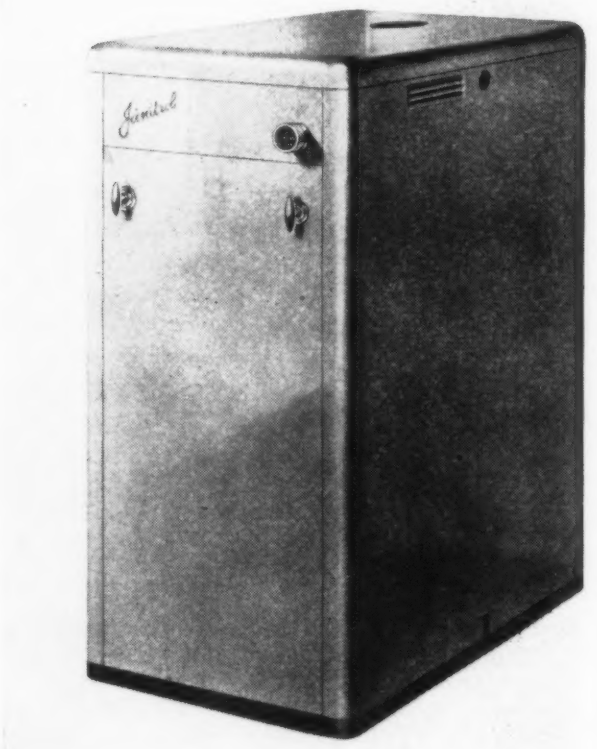
Thus, the handles indicate the location of elements of the system.


EXPANSION TANK AND AIR ELIMINATOR
AIR VENT FOR FILLING SYSTEM
STOP AND WASTE VALVES FOR GARAGE UNIT
WALL HUNG GARAGE UNIT
2 INCH CONCRETE BASE
SUPPLY HEADER
TEES TO DRAIN SYSTEM
RETURN HEADER
ALL PIPES AND TUBING IN UNHEATED SPACE SHOULD BE INSULATED.

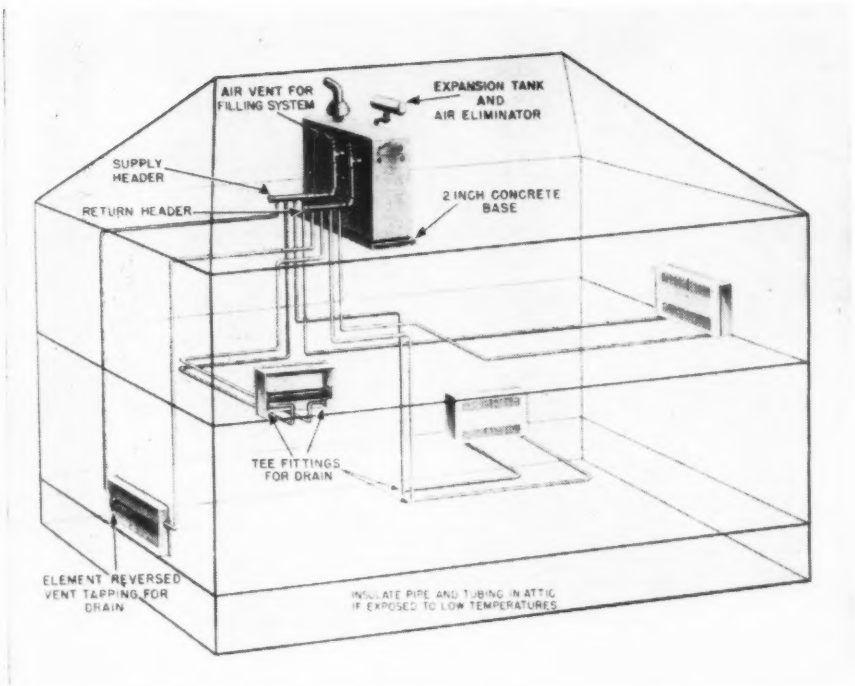
LIVING room floor installation in a one-floor home. Garage is heated, but convector can be shut off at furnace if desired.

Triple Service Hot Water Heating System

This "triple service" gas or oil fired hot water heating system provides water at controlled temperatures for home heating, hot water for automatic home laundries and dishwashers, and tempered water for lavatory, tub and shower. Including a mechanical means for water circulation, either recessed or open radiators can be used. Radiant panel-type installations can also be used with this system. Since all three units are combined in a single unit, the floor area required by the unit is less than that required by separate units. The unit is designed according to the Boiler Code of the ASME. Water, passing through a coil in the boiler, is supplied directly to laundry and similar services. For "tempered" water services it is mixed with cold water. With 100F rise above supply temperature, output is 90, 135, or 185 gal per hr for the three sizes available. Tempered water, where 63F rise is usual, is thus available in double these volumes. The system is available in 100,000 btu 150,000 btu and 210,000 btu per hr sizes. It is manufactured by the Janitrol Division of the Surface Combustion Corporation, Toledo, Ohio.



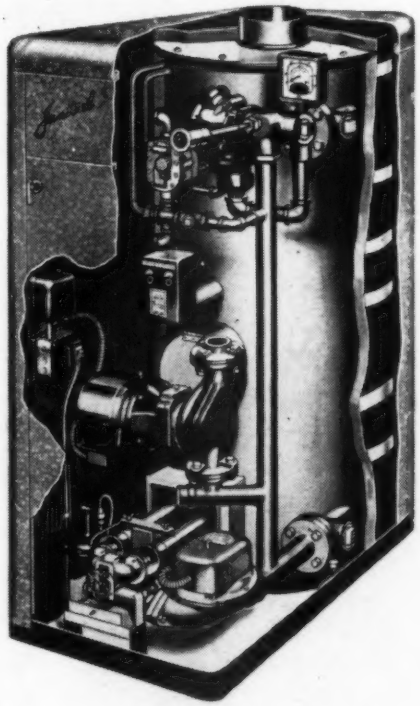
CABINET of the "triple service" hot water heating unit is finished in smooth gray baked-on enamel. All automatic controls are inclosed. Modulating control, to "tune" the system to prevailing outside weather conditions, extends through the top of the upper front panel section. Front panel can be removed by means of the handle-type latches. The cabinet panels are slotted to provide ventilation for the burner and pump units. Unit is completely assembled at the factory.


AIR VENT FOR FILLING SYSTEM
EXPANSION TANK AND AIR ELIMINATOR
SUPPLY HEADER
RETURN HEADER
2 INCH CONCRETE BASE
TEE FITTINGS FOR DRAIN
ELEMENT REVERSED VENT TAPPING FOR DRAIN
INSULATE PIPE AND TUBING IN ATTIC IF EXPOSED TO LOW TEMPERATURES

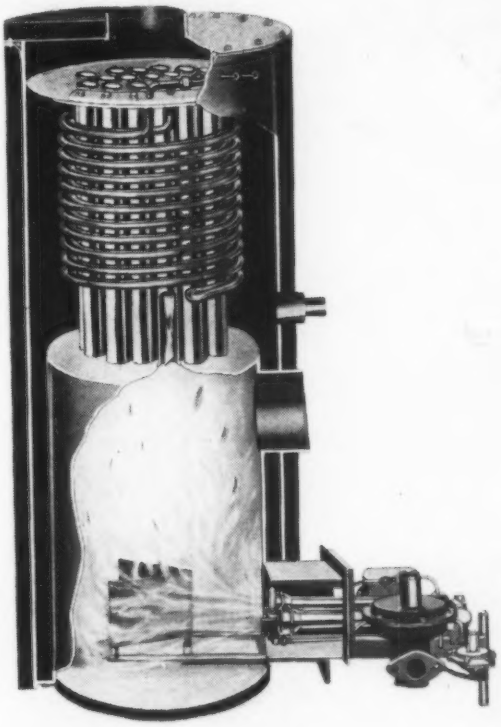
ATTIC installation in a two story house. Each convector has separate piping.

SYSTEM OPERATION

OPERATION of the system is entirely automatic. A room thermostat functions to start and stop the water circulating pump to provide desired room temperature. Normal water temperature range is from 205 F to 215 F. A limit control prevents temperature from exceeding 220 F. When temperature drops to the low limit, burners are started and operated until the 215 F temperature is reached. With normal water pressure of 8 to 10 psi, operating pressure is 15 psi. A relief valve prevents the pressure from exceeding 30 psi. Automatic flow control valve prevents gravity water circulation when pump is not operating. An "air eliminator" installed above the heating unit prevents air from accumulating in the system. This unit also acts as an expansion tank to prevent excessive pressure from water expansion.



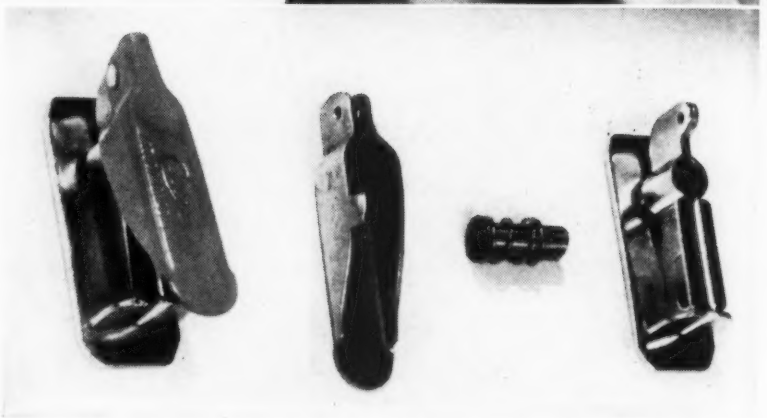
CABINET CUTAWAY shows the compact arrangement of the controls and burners in front of the heat generator. Heavy insulation around the $\frac{1}{4}$ in. thick boiler is also cut away to show its interior. A disc of insulation is placed on the bottom of the generator. The motor and circulating pump unit is mounted above the burners. Tubing for connections to convectors is double wall steel type, copper coated internally and copper and solder coated externally.



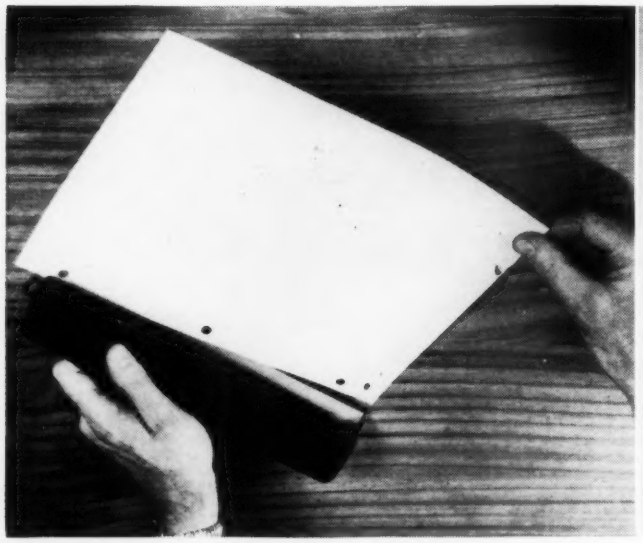
BOILER CUTAWAY shows the copper utility water heating coil that surrounds the boiler tubes and is immersed in the water used for heating. Coil is double wrapped with inlet and outlet at the top passing through a removable plate attached to the top of the tube sheet. Coil can be removed by taking off top plate and unwinding the coil through the tube sheet opening. Since the heating water is circulated in a closed system, it can be treated for scaling.

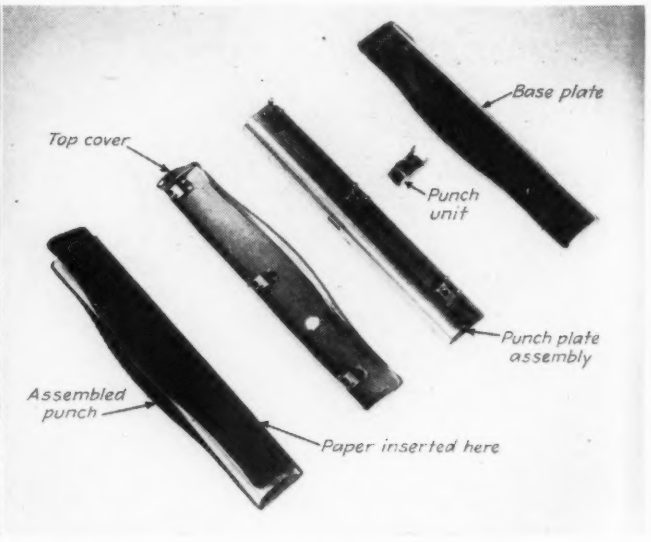
Design for Welded Stampings Reduces Cost of Paper Punches

These paper punches, assembled from welded stampings are sold for approximately one third the price of those using castings. Material is cold rolled steel with thicknesses and tempers selected to meet the fabricating and functioning requirements of each part. Components are assembled by spot welding, riveting and staking. Punches are made by New England Pressed Steel Co. for the New England Paper Punch Co., Natick, Mass. The two punches take care of all normal requirements for loose-leaf devices.



SINGLE HOLE PUNCH, Model 100 is used for varied hole spacings. Lever eases punching of thick, hard papers. Left and right guide stampings are spot welded together and staked to base. Rivet hinges operating lever to guide assembly. Base is 0.072 in. hard cold rolled steel. Other stampings are softer 0.050 in. material.

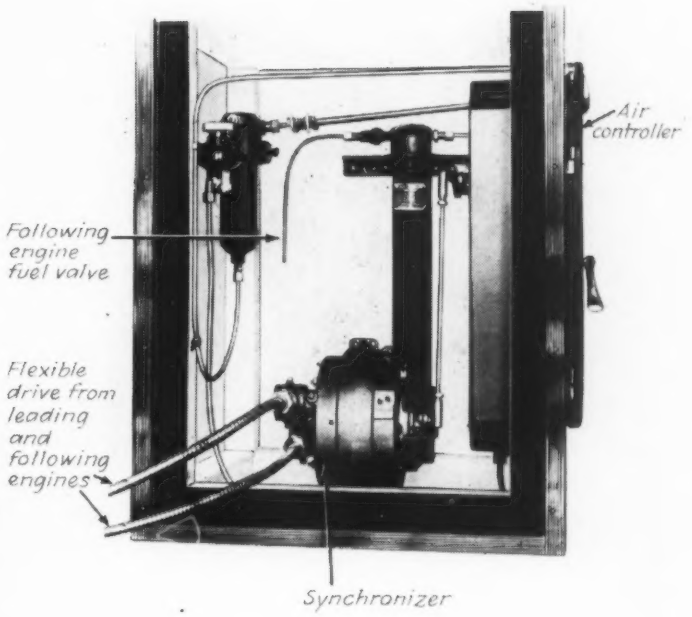


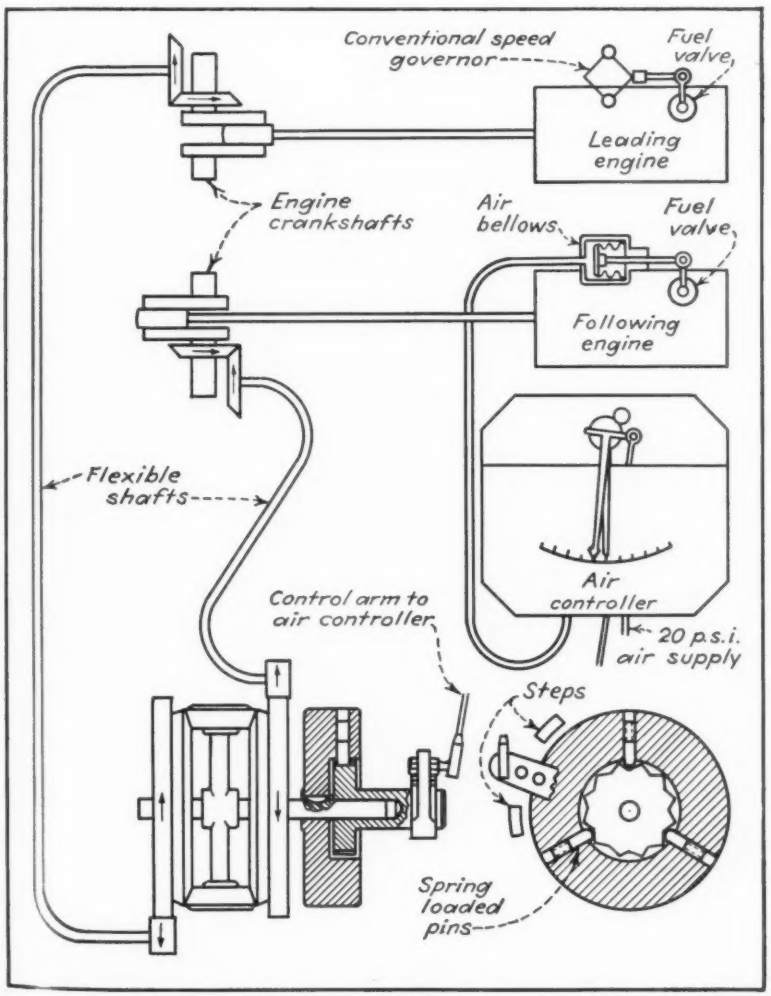


MODEL 3 with holes on 4½ in. centers meets about 85 percent of the requirements for this type of punching. A curved lower plate guides paper into place under punches. Punch components are principally cold rolled steel. Base plate is 0.032 in. thick with retaining spring riveted on. It retains punchings. Each punch unit consists of a 0.062 in. punch holder stamping, punch, spring, and retainer. The three units are spot welded to 0.072 in. lower punch plate. 0.025 in. thick upper plate is welded to lower punch plate. Three hinges are welded to 0.032 in. thick top cover to mate with pierced lugs on punch units. Pointed wire hinge pin is inserted through hole in end of top cover to complete assembly. Exterior of this model is finished in black wrinkle lacquer.

Engine Synchronizer Controls Speed and Phasing

The Synchro-Master engine synchronizer uses a differential gear set to measure speed and phase differences between two engines or between one engine of a group and a reference standard such as an electric motor. An overrunning clutch with positive angular locating feature permits sensitive angular adjustment of the units for best relationship of unbalanced rotating masses but avoids damage by high speed differences during synchronizing process.



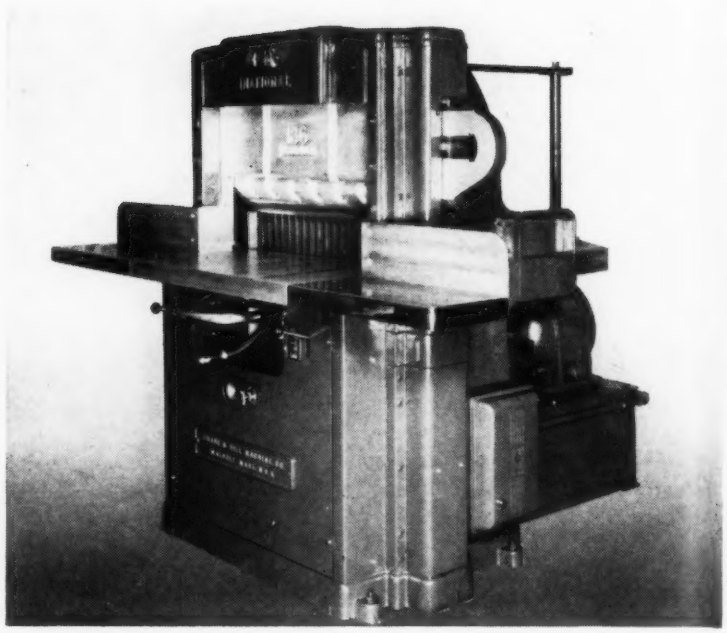


CONTROLLER MECHANISM includes measuring unit described below and standard air operated controller unit which supplies force for operation of engine fuel controls. The system was developed by R. H. Granville of the Synchro-Master Co., Seneca Falls, N. Y.

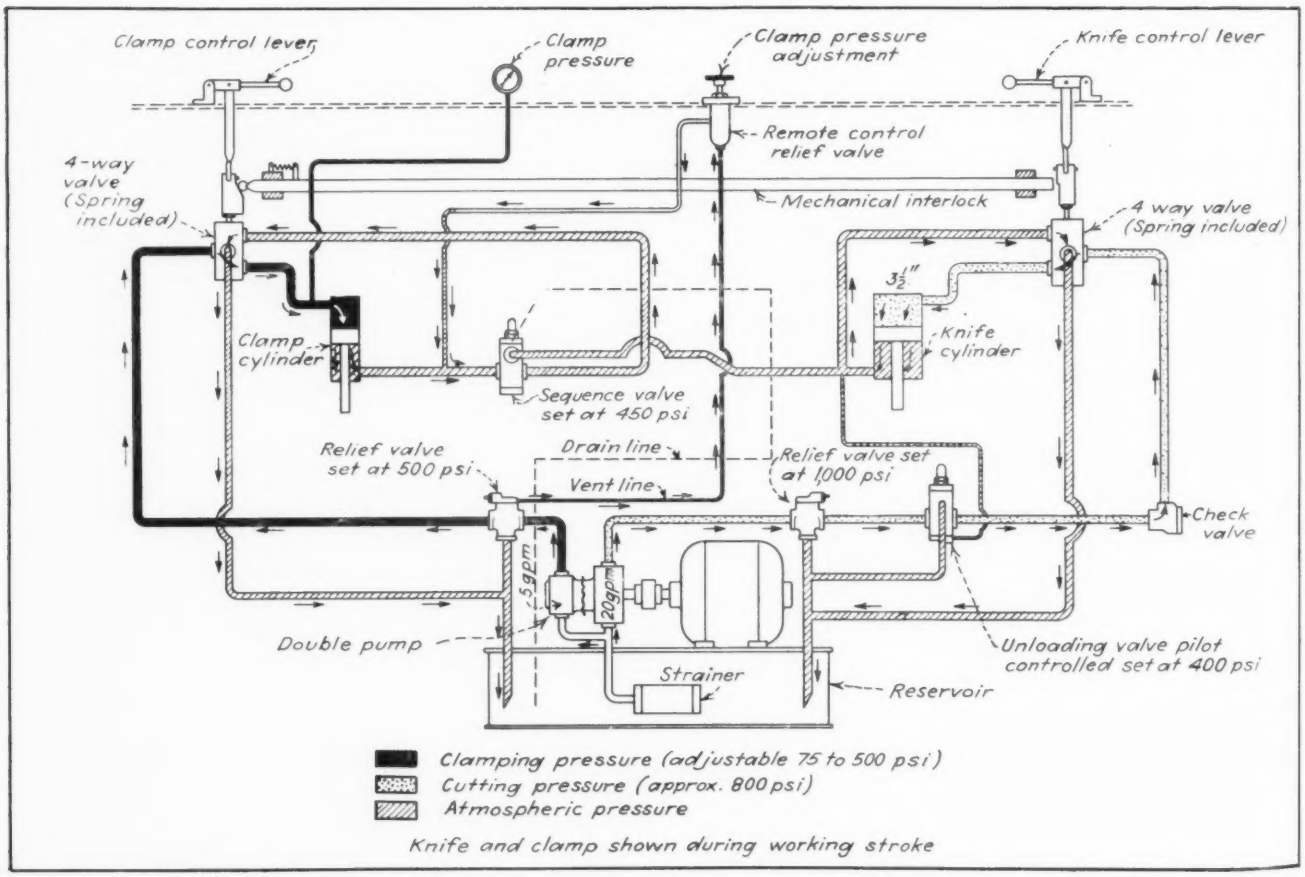
SPRING-LOADED pins allow outer member to rotate if unequal speed of engines continues after lever on inner part of clutch is brought against stops. This prevents damage to control linkage. Angular interval between teeth corresponds to one engine revolution. This interval permits control of engine phase relation by adjustment of air controller set pointer. When relative speed of engine changes, resulting change in speeds of differential input gears causes spider shaft and clutch housing to rotate. This rotates inner member of clutch, which displaces moving pointer of air controller through connecting linkage. Air controller output varies fuel supply to following engine until its speed equals that of leading engine. Phase relationship is measured by angular position of spider, when speeds are synchronized, and transmitted through clutch and linkage to moving pointer of air controller. Air controller adjusts following engine to desired phase relation by matching moving pointer to set pointer. Leading engine is controlled by conventional speed governor or other means.

Complete Hydraulic Operation Simplifies Paper Cutter

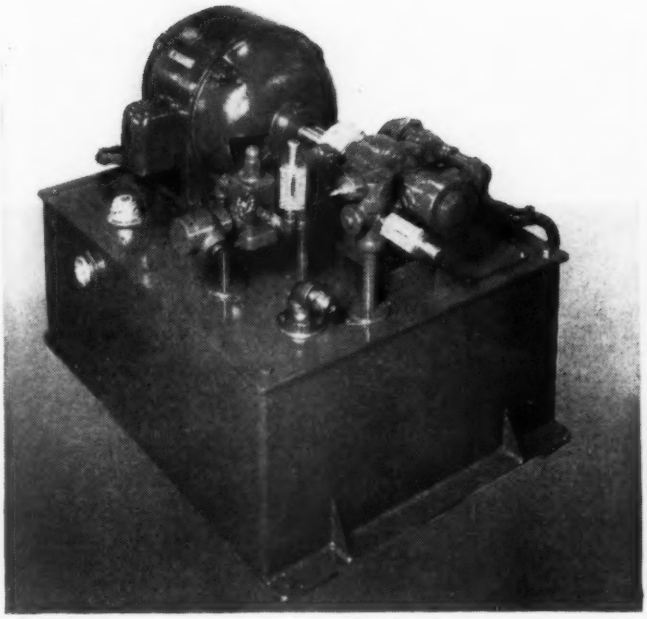
Sensitive adjustments of clamping pressure is accomplished by hydraulic system in 36 in. guillotine paper cutter. Knife is also moved by hydraulic cylinder to simplify design. Machine normally cuts with shearing stroke but may be adjusted to vertical for cutting sheet plastics, or notching. R. C. Eckler of Barkley and Dexter, Boston, Mass. designed the cutter for the F. M. Hill Machine Co. of Walpole, Mass. The complete unit weighs 5750 pounds.



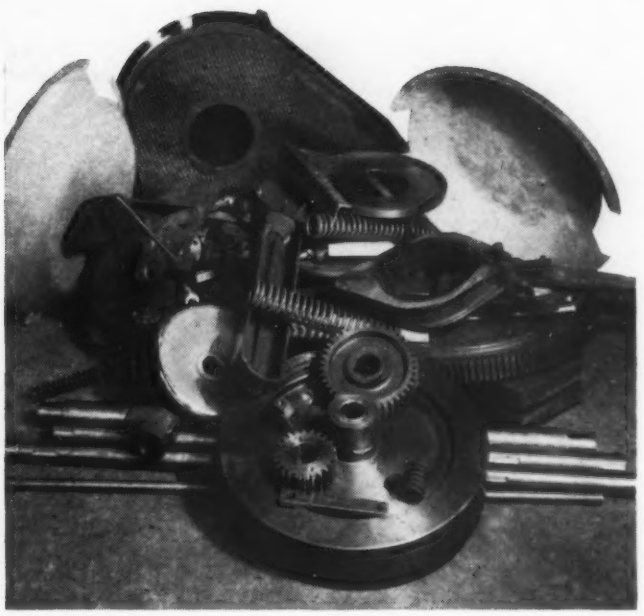
BOTH HANDS must be used to operate cutter and cycle will not repeat. This meets safety law requirements. Machine frame is cast iron. Hinged cover over knife holder is aluminum.



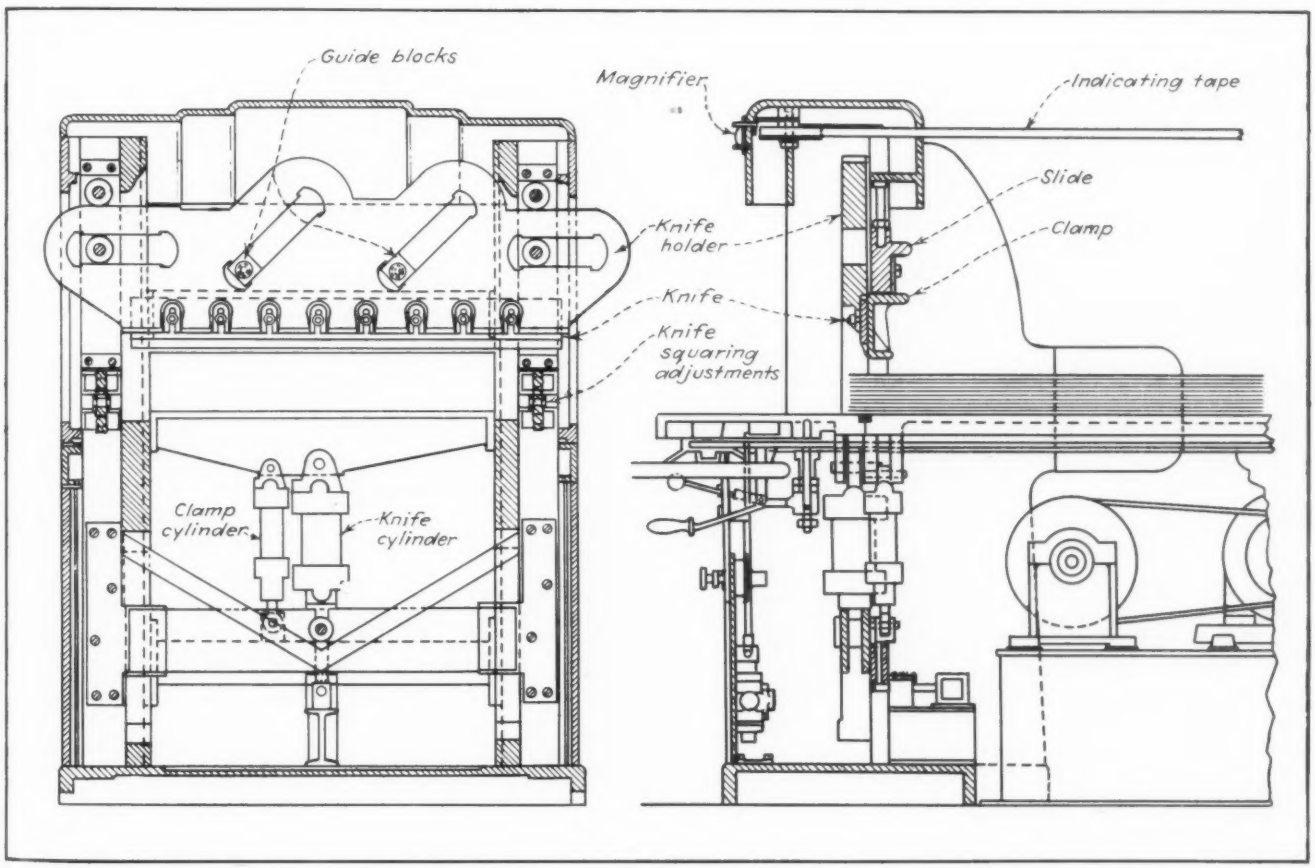
HYDRAULIC SYSTEM. Interlock blocks knife control lever until clamp lever has been activated. Knife control must be held down until cutting stroke is completed. Clamp may be applied at selected pressure several times to smooth out paper. After clamping, stock may be nicked and knife raised again before completing cut. In up position small pump supplies pressure to hold up clamp and, through sequence valve, knife, it also trips unloading valve on large pump to reduce power consumed while cutter is idle. Pumps are driven by 7½ hp motor.



HYDRAULIC PUMP consists of two units. 1000 psi pump feeds knife cylinder, smaller unit is regulated to give desired clamping pressure. Oil supply is stored in base.



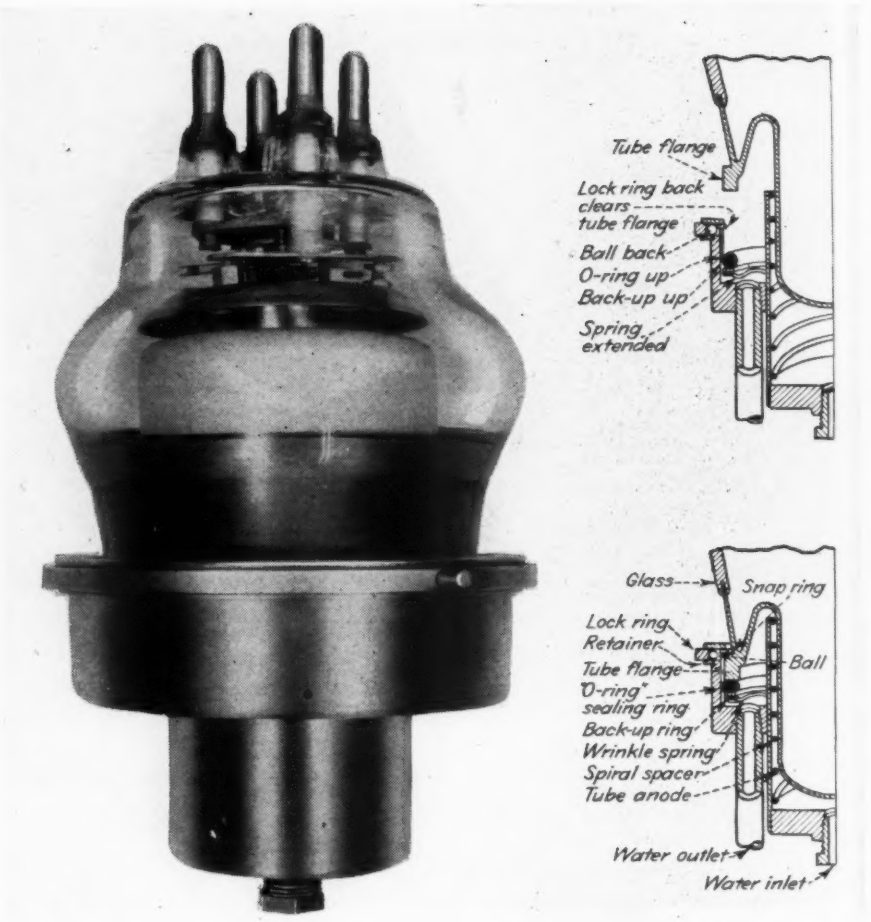
FORMER completely mechanical cutter required 183 parts not needed in the hydraulic model. Lubrication and maintenance were also more difficult operations.



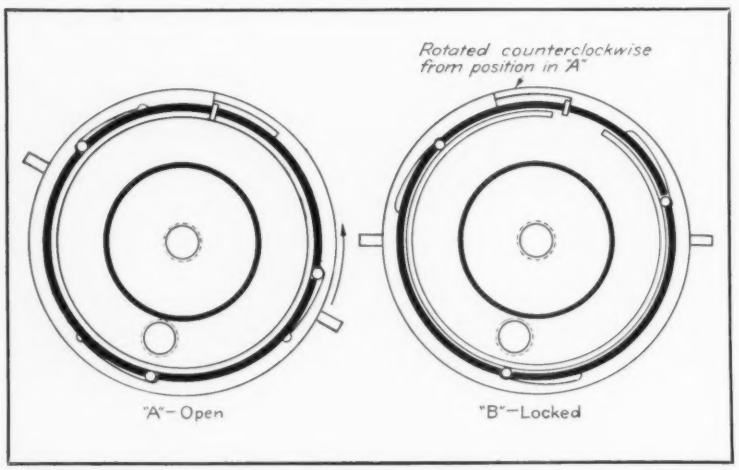
SECTIONAL VIEWS show knife mechanism. Clamp must be lowered first, then, when knife descends, slide contacts top of clamp assembly and stops downward movement of guide blocks when knife approaches paper. As knife continues down, upper sides of angular slots bear on guide blocks and force knife holder and knife to left to give shearing action. Machine can be adjusted for vertical cut. Illuminated, indicating tape for back gage is read through magnifier at eye level. Clamp and knife are mechanically locked in raised position when power is off.

Cooling Jacket Accepts Varied Dimensions of Tubes

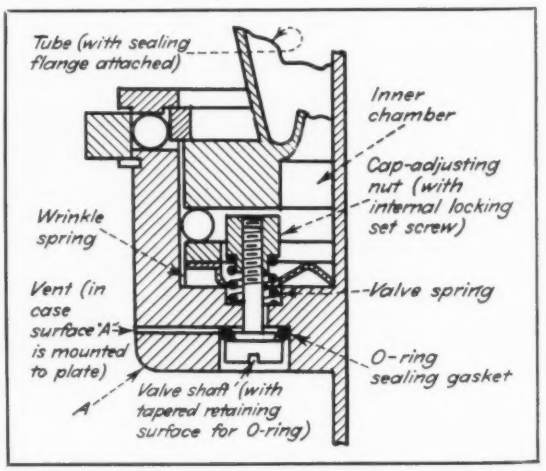
Variations in dimensions of water-cooled electronic tubes are compensated in new cooling jacket designed for Machlett Laboratories, Springdale, Conn. by G. Hamlin Leonard. Finger-tip operation facilitates desirable periodic cleaning of cooling surfaces. O-ring gasket and internal stops fix correct gasket pressure for tight seal and prevent distortion of anode. Because large anode area results in high hydraulic forces when cooling system is in operation, a safety feature prevents release of tube while water pressure is applied. A vacuum-relief valve facilitates removal of tube when system imposes a vacuum on the cooling jacket.



TUBE ANODE floats under lock ring to best cooling position as located by helical spacer in jacket. Wrinkle spring holds O-ring against anode flange. Water pressure produces necessary sealing action.

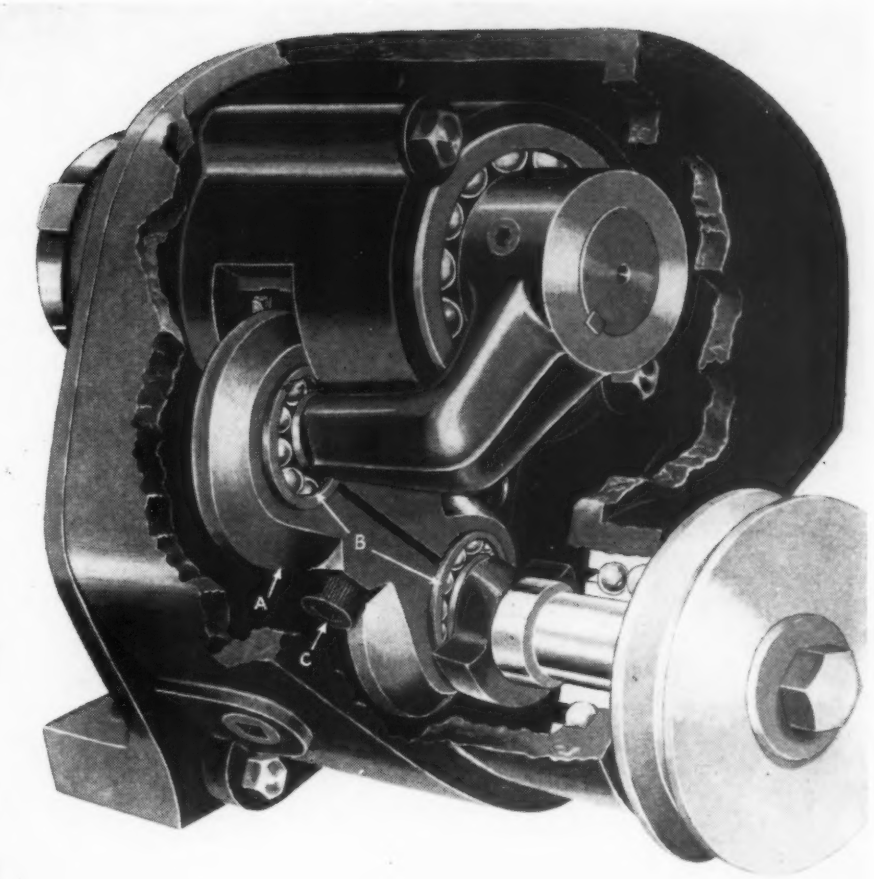


ROTATION of operating ring cams stainless steel balls through holes in jacket body to contract lock ring above tube flange. Cam grooves have dented notches at "closed" ends to prevent self unlocking under lock ring pressure and vibration. Tube cannot be released until water pressure has become negligible because hydraulic load will bind lock ring axially against retaining shoulder (see above). This prevents lock ring from springing open even if operating ring is rotated to "open" position.


Tube (with sealing flange attached)
Inner chamber
Cap-adjusting nut (with internal locking set screw)
Wrinkle spring
Valve spring
Vent (in case surface "A" is mounted to plate)
O-ring sealing gasket
A
Valve shaft (with tapered retaining surface for O-ring)

VACUUM relief valve is necessary because vacuum in some cooling systems, when shut down, holds tube tightly in jacket. Under vacuum, tube moves down in jacket compressing wrinkle spring and unseating valve. Large area of tube assures positive unseating under vacuum yet permits strong relief valve spring for tight sealing under working pressure.

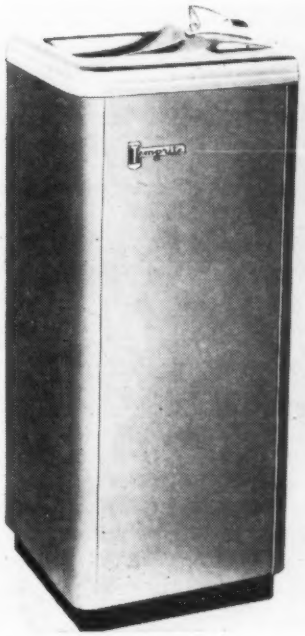
Alignment Assured by Split Link



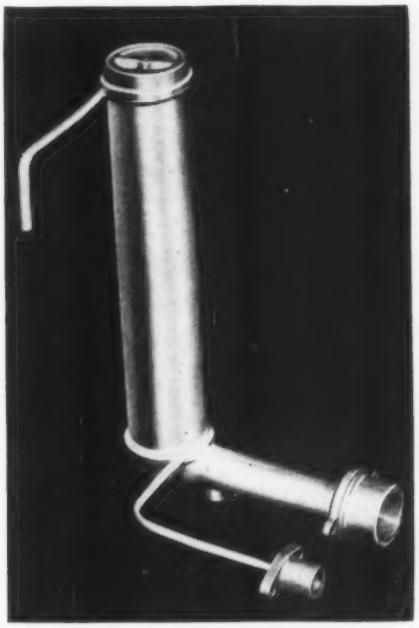
A split connecting link A is clamped to outer races of bearings C after assembly of this comb box. This automatically locks the bearings in proper alignment. Access to the clamping screw C is obtained through lubricating plug hole in housing. Since the comb box is used on a textile carding machine, tight construction was desired to avoid oil leakage. Former designs required frequent adjustment due to severe stresses imposed by oscillations up to 1700 cycles per min. To overcome these stresses a rigid housing and standard ball bearings were selected by J. C. Caldwell of the Southern States Equipment Co., Hampton, Ga.

Steel Stamping Forms Water Cooler Top

Temprite water cooler made by Temprite Products Corp., Detroit, Mich. cools 10 gallons per hour of 80 deg F water to 50 deg in an ambient temperature of 90 deg. Air cooled condenser is standard but a water cooled model is available to meet unusual conditions. The cooling unit is designed to prevent damage from an accidental freeze-up. Cooler meets National Bureau of Standards specifications. Sundberg-Ferar of Detroit, Mich. styled the model.



TOP is drawn 18-8 stainless steel with anti-splash guard included in stamping. Bubbler is designed to user's lips and waste water cannot contact nozzle.



PRECOOLER increases capacity and economy of system by using cold waste water to cool incoming supply before it flows to cooler and storage tank.

Table I—Characteristics of Brass Powder and Sintered Compacts

Powder No.	Nominal Composition Cu	Zn	P	BRASS POWDER: Nominal Screen Size	Flow (3) Seconds Per 50 grams	Bulk Density, Grams per cc	Green (4) Strength, Percent Weight Loss	Optimum Sinter Temperature deg. C	deg. F	SINTERED COMPACTS (2): Sintering Range deg. C	deg. F.	Tensile Strength, lb. per sq. in.	Elongation, Percent	Weight Loss, Percent	Change in Length, Percent
				IRREGULAR PARTICLES						IRREGULAR PARTICLES					
1110	90	10		(5)−100	36 to (1)	2.9–3.2	0.6	920	1688	840–920	1544–1688	32,000	14	0.4	−0.3
1109	85	15		−100	34	3	0.5	920	1688	860–920	1580–1688	39,000	20	0.6	−0.4
1130	80	20		−100	48*	2.5*	0.5*	900	1652	860–900	1580–1652	40,000*	30*	0.8*	−0.3*
1101	70	30		−100	33 to (1)	2.6–3	0.3–0.5	900	1652	880–900	1616–1652	36,000	14	2.1	−1.4
1107	65	35		−100	33–40	2.75–3	1.0*	890	1634	880–890	1616–1634	39,000*	22*	2.3*	−2.2*
1119	60	40		−100	38–48	2.4–2.8	1.7*	890	1634	880–890	1616–1634	44,000*	20*	3.6*	−3.2*
1113	90	10	0.5	−100	36 to (1)	3	0.6–0.7	900	1652	840–920	1544–1688	32,000	34	0.4	+0.4
1104	70	40	0.3	−100	33 to (1)	2.6–3	0.5–0.6	850	1562	820–860	1508–1580	36,000	48	0.5	−1.4
1125	65	35	0.3	−100	34	2.9	0.9*	845	1553	820–850	1508–1562	39,000	42*	1.4*	−2.3*
1114	60	40	0.1	−100	41	2.6	1.8–2.1	870	1598	860–880	1580–1616	50,000	34*	5.0*	−2.6*
				SPHERICAL PARTICLES						SPHERICAL PARTICLES					
1117	70	30	0.3	−100	15	5		850	1562	820–860	1508–1580	36,000*	48*	0.5*	−1.4*

* Properties determined on −200 mesh powder only.
(1) Intermittent flow.
(2) Compacts pressed at 50 tons psi and sintered at optimum temp. in dry hydrogen.
(3) Time required for 50 grams to flow thru. 1 in. dia. orifice in Hall Flowmeter.
(4) Arbitrary test. Weight loss from 5 compacts ½ in. dia. by ¼ in. thick compressed at 50 tsi and rotated 1000 rev. in a 3⅜ in. dia. screen cage at 87 rpm. Thus the higher the weight loss, the poorer the green strength.
(5) Minus sign indicates that the powder is predominantly finer than this screen size.

Nonferrous Metal Powders

Physical properties of brass, copper, zinc and bronze powders made by the atomization process. The effect of phosphorus on brass powders. How sintering conditions affect parts.

D. C. BRADLEY
Market Development Division
The New Jersey Zinc Company

THE SELECTION of metal powders for the fabrication of acceptable finished parts depends upon the physical characteristics of the various types that are available and on the temperature range in which they can be sintered. The powders discussed here are: brass, copper, bronze and zinc made by the atomization process.

Brass Powders

When selecting a brass powder, the prospective user usually has wide limits of composition from which to choose. The actual selection is based upon a composition that will yield the fewest fabrication problems and yet give certain minimum mechanical properties.

TYPES. Brass powders are divided into two classes: Those of irregular particle shape and those of spherical particle shape. The irregular particle shapes are further subdivided into straight brass powders and brass powders mechanically mixed with phosphor-copper to yield a specified percentage of phosphorus.

Irregular brass powders are irregular masses having rough surfaces. Frequently they have flaky or acicular projections. This condition is illustrated in Fig. 1. These powders are used in normal powder metallurgy fabrication using compacting and sintering processes. Their irregular surfaces provide a mechanical bond in cold compacting. Thus, the green compacts have some strength to resist handling during removal from the press and placing in the sintering furnace.

Spherical brass powders are, as the name implies, truly spherical in shape. This is illustrated in Fig. 2. Powders of this type are used in the fabrication of filters where carefully graded sizes with controlled porosity are required, even after sintering. They have poor green strength and are usually held in a form or mold during the sintering process.

PROPERTIES. In Table I are shown the physical characteristics, sintering temperatures and mechanical properties of common brass powders. Since the sintered properties were determined under laboratory conditions, they give valid comparisons between different powders, rather than properties that can be duplicated in regular commercial runs.

PHOSPHORUS ADDITION. The presence of phosphorus addition is most effective in powders having a relatively low copper content. For example, in a brass powder composed of 70 percent copper and 30 percent zinc, phosphorus reduces the optimum sintering temperature from 900C to 850C. It also broadens the sintering range from 20C to 40C. This factor is extremely important in commercial sintering operations where control to plus 10C is unusual.

The effect of phosphorus addition to a 70-30 brass powder can be seen in

Table II—Properties of Specimens Made from Brass Powder

	70-30 BRASS				90-10 BRASS			
	1101		1104		1110		1113	
Compacting Pressure (tons per sq. in.)	30	50	30	50	30	50	30	50
Sintering Temperature (deg. C.)	900	900	850	850	920	890	910	880
TENSILE BARS								
Yield Point (psi. 0.2 percent offset)	15,900	18,800	8,600	8,800	11,500	14,100	9,200	10,300
Elastic Modulus (10^6 psi.)	13.2	16.3	11.9	13.9	16	16.7	11.4	12.9
Tensile Strength (psi.)	29,100	35,200	32,000	34,900	26,100	28,400	27,400	29,700
Tensile Elongation (percent in 1 in.)	11	13	43	50	15	13	31	34
Brinell Hardness (10 mm ball, 250 kg load)	43	51	35	39	38	49	35	41
Density (grams per cc)	.....	7.92	.....	7.94	.....	8.36	.....	7.99
SPECIMENS $\frac{1}{4}$ in. by $\frac{1}{4}$ in. by 3 in.								
Shear Strength (psi.)	28,800	32,300	25,600	26,000	24,800	25,000	23,500	24,500
Charpy Impact (unnotched, ft.-lb.)	11	13	22*	25*	11	13	25*	27*
Thermal Conductivity (Cal/sec/sq cm/cm/deg. C at 75 C)	0.226	0.253	0.177	0.218	0.358	0.386	0.157	0.170
Thermal Expansion (10^{-6} mm per C)								
25 C to 100 C	17.7	18.2	18.4	18	17.1	16.9	17.1	17.4
25 C to 300 C	19.3	19.1	19.6	19.5	17.9	18	18.4	18
SPECIMENS $\frac{1}{4}$ in. by $\frac{1}{4}$ in. by $\frac{3}{4}$ in.								
Electrical Conductivity at 25 C (Percent of Int'l Annealed Copper Std.)	22.11	25.17	17.19	19.06	33.24	35.72	14.35	16.51
SPECIMENS $\frac{1}{2}$ in. dia. by 0.45 in.								
Compressive Strength (psi. 10 percent compression)	38,300	43,200	29,500	31,600	34,600	39,000	31,400	32,700

* Pulled through without fracture.

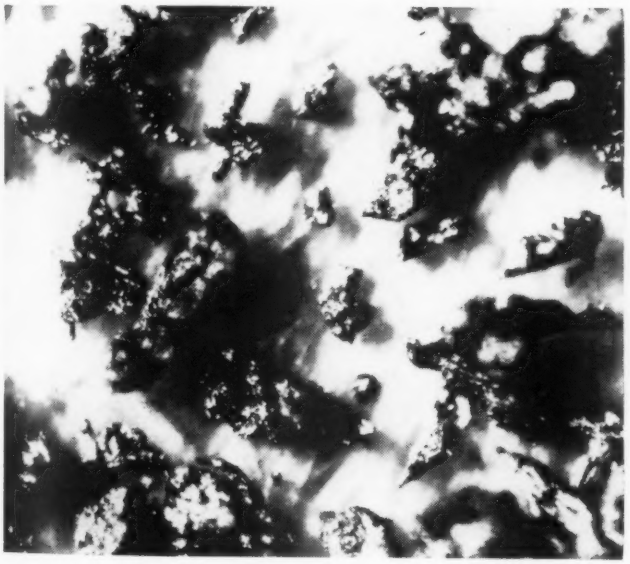


Fig. 1—**Irregular brass powders have good green strength.**

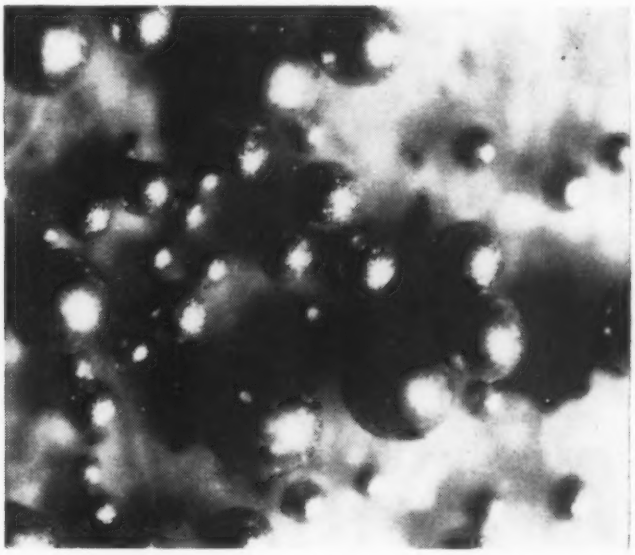


Fig. 2—**Spherical brass powders have poor green strength.**

Table I by comparing the values for the 1101 and 1104 powders. It has approximately quadrupled the ductility of the sintered compacts without affecting the other properties.

In 90-10 brass powders, phosphorus has no marked effect on the sintering range or the optimum sintering temperature. But it does increase the ductility of the sintered compacts. This is shown in Table I by comparing the percent elongation of 1113 powder with that of 1110 powder.

The phosphorus additions are made in the form of extremely fine powder and may segregate during shipment or handling operations. Shipments of this powder should be remixed upon receipt and occasionally during use. This does not apply to spherical powders where phosphorus is present as an alloy ingredient in each powder.

EFFECT OF COPPER. The alpha brasses, composed of 70 percent and higher copper, offer the advantage of better green strength, increased sintering range, lower weight loss and better dimensional control than the harder beta brasses composed of 65 percent and lower copper. Thus, if a part is complicated or has sharp contours, an alpha brass should be used.

Differences in tensile properties resulting from copper content are so small that a choice on this basis alone is made only when maximum strength or ductility is required.

The most important effects of copper are in the sintering range and temperature effects and the change in weight and dimension caused by sintering. There is a definite advantage in using high copper content powder because of the increased sintering

Table III—Evidence of Sphericity of Copper Powder

Number	Apparent Density, Grams per cc	Flow, Sec.
1003	4.67	23
1004	4.89	19
1005	4.9	16
1002	4.92	15
1006	5.35	18
1007	5.35	12
1008	5.35	10

range. Unless phosphorus is present, the sintering range is so restricted when copper content is less than 70 percent, that it is rarely possible to obtain maximum tensile properties in commercial sintering. When close control of weight loss and dimensions are important, high copper content powders have an advantage over powders low in copper.

The atomized brass powders either with or without phosphorus addition offer a wide range of colors and melting ranges for use in brazing or spray gun coating. The beta brasses are widely used for brazing operations.

SINTERING. Most sintering difficulties encountered in past brass powder fabrication have been related to moisture content of the sintering atmosphere. Moisture may enter the furnaces with the sintering gas. It may infiltrate through the doors or other cracks. Or it may result from deoxidation of the charge or the metal racks. The entering gas should be dried and the furnace sealed as tightly as possible. The flow of gas must be adjusted to scavenge the deoxidation process. To insure good results, the moisture in the sintering atmosphere must be held below 2 percent by volume. Moisture content is determined most conveniently by an instrument of the Dew-Point Potentiometer type.

Pure hydrogen yields the best results of the sintering media. Various cracked gases also provide excellent operation. These gases give improved conditions with high hydrogen and low CO_2 contents.

Superficial studies of salt bath and high frequency induction indicate that these methods of heating may open new fields of development.

SPECIMEN PROPERTIES. In Table II are shown the properties obtained on various specimens made from 70-30 and 90-10 brass powder. The tensile bars were ASTM standard proportions. This table provides data on the effect of compacting pressures. Physical characteristics that permit comparisons with wrought or cast metals of similar composition are given.

Copper Powders

Copper powders made by the atomization process are spherical in particle shape. Thus, they are difficult to compact because of poor green strength. Since much of the spherical copper powder made is used in filters where low oxygen content is desired, these powders are made in two grades. The first grade is a pure copper having normal oxygen content. The second grade is copper plus phosphorus having a low oxygen content.

The sphericity of these powders is indicated in Table III where apparent density and flow are given. These powders are shown magnified in Fig. 3. Phos-copper powder is essentially copper-phosphorus eutectic having 8.4 percent phosphorus. This eutectic melts at 714C. It is spherical in shape and particularly suitable for brazing.

Zinc Powders

These powders are also made by atomization and are called Metallic Zinc Powders, so that they will not be confused with zinc dust, a material made by a different method for a different purpose. Zinc powders are all irregular in particle shape as illustrated in Fig. 4.

Zinc powders are generally not designed for powder metallurgy fabrication. This is true principally because zinc powder compacts cannot compete economically with low cost die casting production. Also, zinc powder is difficult to sinter. Zinc powders are used for spray coating, rubber loading and chemical reactions.

Bronze Powders

Atomized bronze powders have each particle completely alloyed but are difficult to compact. Bronze powders without phosphorus have irregular particles and can be used for brazing, spray gun surfacing or for compacts where dense structures are not required. In the compositions containing phosphorus, the particles are spherical and suitable for filter designs.

EDITORS NOTE: An article dealing with actual parts made from brass powders will appear in the October issue of PRODUCT ENGINEERING. In this sequel are discussed some of the cost savings made by specifying brass powdered parts to replace parts previously made by other processes. Actual dimensional tolerances that are maintained in production are given.

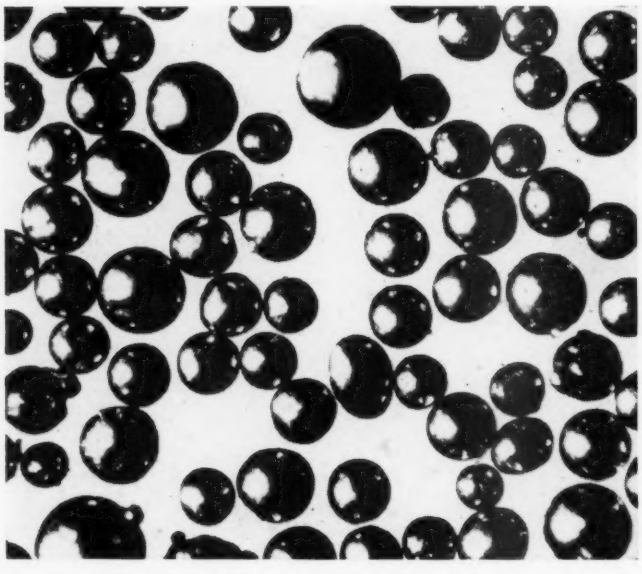


Fig. 3—Copper powders, being spherical, are difficult to compact.

Fig. 4—Zinc powders are spherical but difficult to sinter.

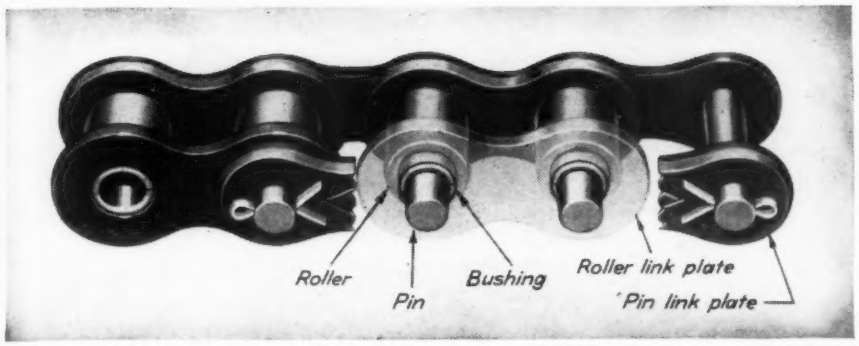


Fig. 1—Arrangement of parts in assembled precision roller transmission chain. Pins and bushings have file hard surfaces. Sideplates are heat-treated medium carbon steel.

Fig. 2—Failures caused by color stripping and plating assembled roller chain.

Embrittlement of Roller Chains By Plating After Assembly

Hazards incurred when assembled precision steel roller transmission chains are electroplated. Technical Committee, Roller Chain Group of the Association of Roller and Silent Chain Manufacturers give reasons why plating of assembled steel roller chain sometimes causes failure of bushings and sideplates.

YEARS OF INVESTIGATION, research, and experience, warrants the conclusion that plating of assembled precision steel roller transmission chains is extremely hazardous. The Association of Roller and Silent Chain Manufacturers advises that the maker cannot and will not be responsible for the service of chains so plated.

Enough nascent hydrogen, it seems, may be absorbed during either acid cleaning or electroplating to cause hydrogen embrittlement of sideplates and bushings, which are under high internal stress from press-fit assembly essential for link rigidity. These parts may crack and split sometime after such treatment, the sideplates radially and longitudinally from the pitch holes and the bushings circumferentially and axially.

Standard assembled steel roller chains have been plated by many purchasers either to improve the superficial corrosion resistance of the chains or to change their appearance. The results are seldom satisfactory and frequently the chain is damaged to the point where it is not safe to use.

It is impossible to plate the inner parts of assembled chain at the areas where plating is needed for corrosion resistance. A uniform covering of external surfaces is seldom obtained because of poor electrical contact.

The operations required to plate assembled roller chain irreparably damage it through hydrogen embrittlement. The exact explanation of the mechanism of hydrogen embrittlement is still a subject for argument, but it is well known that hardened steel under stress will crack if subjected to nascent hydrogen originating through corrosion, acid cleaning, and electroplating. The hardened steel main spring in a watch will give years of service under normal operating conditions. But prompt failure will follow any attempt to acid clean or to electroplate a wound watch spring.

The steels required for and the stresses purposely introduced into the assembled parts of a roller chain are similar to those in the wound watch spring. Similar failures may be expected if stressed parts of roller chain are acid cleaned or electroplated.

Roller chain is constructed as shown in Fig. 1. To provide the strength required for normal service, the sideplates are commonly made from medium carbon steels heat-treated to Rockwell "C" 40-45. For wear resistance the pins and bushings are carburized and heat-treated to produce a file hard surface.

Bushings and pins are retained in their respective sideplates by press fits, which must be great enough to prevent any movement between these fitted parts in service. The required resistance to movement is not obtained until the press fit is sufficient to cause the steel around the pitch hole of the sideplate to be slightly deformed plastically.

Sideplates and rollers of standard roller chains are usually oxidized (colored straw, blue or black) to provide an attractive appearance and some resistance to superficial rusting. It is not possible to apply a satisfactory plate over this oxide layer. Although the layer can be removed in inhibited weak acids, there is grave danger that enough hydrogen will be evolved to make the steel so brittle that the sideplates will crack or split and the bushing will crack or break down circumferentially.

In the electroplating process, the object to be plated must be the cathode. Even under carefully controlled conditions, enough nascent hydrogen will be evolved and absorbed by the steel in the assembled roller chain parts to cause embrittlement. In Fig. 2 are shown typical failures that result from the operations of color stripping and plating.

Cracked sideplates cannot support normal service loads, therefore, under such loads the chain may break apart completely. Cracked bushings will break up under normal service and repaid wear will result.

Experiments undertaken to study the exact mechanism of hydrogen embrittlement have proved that roller chain parts of the same analysis, metallurgical characteristics and mechanical fits will not always fail when electroplated under the same test conditions. But failures occur often enough to conclude positively that electroplating of roller chain is not a safe practice.

A NUMBER of bimetal shapes. Bimetal parts can be used to establish electrical contact, or apply load or control force.

Thermostatic Bimetal

Thermostatic bimetals for controls. Functional applications showing uses, load and deflection formulas and time response characteristics.

ERNEST R. HOWARD
The H. A. Wilson Company

MANY MACHINES, electrical products and instruments owe their good health to a small bimetal part designed to safeguard them against the occupational hazards of their trade. Properly chosen for certain electrical or mechanical properties, this simple, cheap element often can outperform a more complicated control device.

Thermostatic bimetals, used in controls, do their jobs by deflecting or by exerting a force when they are heated either by the medium that surrounds them or by an electric current flowing through them.

In practice, bimetal strips are made by bonding heavy plates of the component metals and then hot and cold rolling the assembly to finished size. Cold rolling determines the final physical properties of the strip. Any subsequent heat treatment usually is for stress relief only. If a finite value of electrical resistance is required, a third strip may be sandwiched in.

Bimetal materials are picked for their temperature characteristics, strength, stability, heat conductivity, electrical resistance or workability. Brass and invar make the cheapest bimetal, but cannot be used above 300 F. For use at higher temperatures, up to 800 F, a stainless steel (usually an iron-nickel-chromium alloy) replaces the brass.

As shown in Table I, bimetals will operate over a fairly wide range of temperature depending on the com-

Table I—Bimetal Constants Used in Load and Deflection Equations

Therm-metal	Temperature Range		Constants for Formulas						
			Straight Strips				Coils		
	Useful Deflection, deg F	Maximum Sensitivity, deg F	Flexivity, ASTM B106-40, F	K	N	B	C	X	Y
Brass-Invar	−100 to 300	50 to 300	0.0000150	0.0000075	525	70,000,000	0.00095	390	410,000
All steel	−100 to 700	50 to 300	0.0000138	0.0000069	690	100,000,000	0.00087	510	580,000
All steel	−100 to 700	50 to 300	0.0000150	0.0000075	750	100,000,000	0.00095	555	580,000
Manganese alloy-Invar	−100 to 500	50 to 350	0.0000214	0.0000107	815	76,000,000	0.00136	600	440,000
All steel	−100 to 700	150 to 450	0.0000134	0.0000067	670	100,000,000	0.00085	495	580,000
All steel	−100 to 900	150 to 450	0.0000146	0.0000073	730	100,000,000	0.00092	540	580,000
All steel	−100 to 1000	300 to 600	0.0000122	0.0000061	610	100,000,000	0.00077	450	580,000
All steel	−100 to 800	300 to 600	0.0000132	0.0000066	660	100,000,000	0.00084	485	580,000
All steel	+400 to 900	500 to 800	0.0000090	0.0000045	415	92,000,000	0.00057	305	540,000
All steel	−100 to 500	50 to 300	0.0000106	0.0000053	510	96,000,000	0.00067	375	560,000
All steel	−100 to 700	300 to 600	0.0000096	0.0000048	460	96,000,000	0.00061	340	560,000
All steel	−100 to 600	50 to 600	0.0000036	0.0000018	180	100,000,000	0.00023	135	580,000
All steel	−100 to 500	50 to 300	0.0000092	0.0000046	460	100,000,000	0.00058	340	580,000
All steel	−100 to 500	50 to 300	0.0000100	0.0000050	500	100,000,000	0.00063	370	580,000
All steel	−100 to 500	50 to 300	0.0000104	0.0000052	520	100,000,000	0.00066	385	580,000
Trimetal (copper core)	−100 to 500	50 to 300	0.0000100	0.0000050	520	104,000,000	0.00063	385	610,000
Tri metals	−100 to 300	50 to 300	0.0000148	0.0000074	520	70,000,000	0.00094	385	410,000
Tri metals	−100 to 700	50 to 300	0.0000144	0.0000072	720	100,000,000	0.00091	530	580,000
Tri metals	−100 to 700	50 to 300	0.0000146	0.0000073	730	100,000,000	0.00092	540	580,000
Tri metals	−100 to 700	50 to 300	0.0000146	0.0000073	730	100,000,000	0.00092	540	580,000
Tri metals	−100 to 700	50 to 300	0.0000144	0.0000072	720	100,000,000	0.00091	530	580,000
Tri metals	−100 to 700	50 to 300	0.0000146	0.0000073	730	100,000,000	0.00092	540	580,000
Tri metals	−100 to 700	50 to 300	0.0000146	0.0000073	730	100,000,000	0.00092	540	580,000
Tri metals	−100 to 700	50 to 300	0.0000148	0.0000074	740	100,000,000	0.00094	545	580,000
Tri metals	−100 to 700	50 to 300	0.0000150	0.0000075	750	100,000,000	0.00095	555	580,000
Tri metals	−100 to 700	50 to 300	0.0000150	0.0000075	750	100,000,000	0.00095	555	580,000
Tri metals	−100 to 700	50 to 300	0.0000150	0.0000075	750	100,000,000	0.00095	555	580,000
Tri metals	−100 to 700	50 to 300	0.0000144	0.0000072	690	96,000,000	0.00091	510	560,000
Tri metals	−100 to 500	50 to 350	0.0000214	0.0000107	815	76,000,000	0.00136	600	440,000

ponent alloys. The first column gives the useful deflection range and the second column the range of maximum temperature response.

Functional Uses

The temperature-deflection properties of bimetal are used for (1) Temperature indication, (2) temperature control, (3) temperature compensation, and (4) sequence control.

For temperature indication, bimetal may be made in a spiral coil or helix. The free end of the coil rotates around its fixed center when temperature changes. If a temperature scale is fitted to the coil, the result is a simple thermometer. Bimetal thermometers are used for temperatures from —100 to 1,000 F and some deflect as much as 3 angular degrees per degree F.

For temperature control, bimetal usually is used as a part of an electric circuit supplying power to a fan, heater, valve or other piece of equipment. The bimetal, usually in strip form, deflects through a certain distance and opens or closes the circuit. A domestic room temperature thermostat is a typical example of this type of operation.

In temperature compensating devices, bimetals are used not for temperature control, but to correct another system variable. One example is an automatic choke for an engine, in which the proper air-fuel ratio varies with temperature. Here a bimetal coil, subject to the temperature of the intake air and receiving some heat from the engine, positions a butterfly valve which controls the volume of intake air so that the proper air-fuel ratio is obtained for any temperature. Bimetal can be used to correct the output of equipment affected by temperature change. One example is an automotive or vibrating contact type voltage regulator. Voltage regulation is obtained by letting an armature and solenoid, impressed with battery voltage, control the generator field current. As battery voltage increases, the pull of the solenoid, tending to separate the armature contact from a stationary contact both in the generator field circuit, increases; this action decreases generator output. Unless the armature is made partially of bimetal, voltage regulation cannot be maintained when the solenoid copper heats or cannot be over-compensated so that desirable higher cold weather charging is obtained.

The fourth of the general uses of

(*continued on page 110*)

Table II—Typical Bimetal Applications

	RESPONSE DUE TO			RESULTS OBTAINED							
					Temperature Control			Sequence Control			
	Ambient Temperature	Auxiliary Heating	Internal Heating	Temperature Indication	Temperature Control	Temperature Limitation	Temperature Compensation	Time Delay	Current Limitation	Sequence Control	Indication
CIRCUIT CONTROL AND PROTECTIVE DEVICES											
Appliance Cord Controls	X		X		X				X		
Circuit Breakers	X	X	X				X		X		
Flashers		X						X			
Fluorescent Lamp Starters	X	X					X	X			
Generator Cutouts	X						X				
Motor Starting Relays	X	X	X				X	X			
Oil Burner Controls	X	X	X		X	X	X	X	X	X	
Overload Cutouts	X	X	X				X		X		
Overload Relays	X	X	X				X		X		
Signal Relays		X					X	X		X	
Stack Controls	X				X	X				X	
Thermal Cutouts	X					X					
Time Delay Devices	X	X	X				X	X		X	
Transformers	X			X							
Voltage Regulators	X						X				
MECHANICAL DEVICES											
Automatic Chokes	X						X	X			
Carburetors	X										
Draft Control	X						X				
Fluid Valves	X				X	X					
Gas Burner Controls	X	X					X			X	
Gas Safety Pilots	X	X								X	
Hydraulic Drives	X						X				
Manifold Heat Controls	X										
Mixing Valves	X				X						
Piston Rings	X				X		X				
Radiator Air Valves	X									X	
Self-Adjusting Brakes	X						X				
Shock Absorbers	X						X				
Steam Traps	X									X	
Weighing Machines	X						X				
HEATING DEVICES											
Air Conditioners	X				X						
Aquarium Heaters	X				X						
Brooders and Incubators	X				X						
Cigarette Lighters	X							X			
Commercial Cooking Devices	X			X	X	X					
Dryers	X				X						
Electric Coffee Makers	X				X		X				
Electric Flat Irons	X			X	X	X	X				
Electric Heaters	X				X	X					
Electric Soldering Irons	X				X						
Electric Waffle Irons	X			X	X	X					
Electric Blankets	X	X			X	X					
Electric Toasters	X	X					X	X			
Exhaust Manifold Heat Control	X				X						
Furnace Stack Controls	X				X	X				X	
Gas and Electric Ovens	X			X	X	X					
Gas and Electric Water Heaters	X			X	X	X					
Gas and Electric Ranges	X			X	X	X					
Gasoline Car Heater	X	X			X			X		X	
Heating Pads	X	X			X						
Hot Beds	X				X						
Hot Plates	X			X	X	X					
Hot Water Limit Switch	X					X					
Ironing and Pressing Machines	X			X	X	X					
Immersion Heaters	X				X						
Orchard Heaters	X							X		X	
Refrigerators	X				X			X			
Roasters	X			X	X	X					
Sterilizers	X				X						
INSTRUMENTS											
Alarm Devices	X			X							
Altimeters	X						X				
Bulb and Bellows	X						X				
Demand Meters	X	X	X								X
Electrical Condensers	X						X				
Electric Fire Detector Clocks	X			X						X	
Liquid Level Gauges		X									X
Meteorological Devices	X	X		X			X				
Pressure Gauges		X									X
Stoker Timers		X	X					X			
Temperature Gauges	X	X		X							
Thermometers	X			X							
Thermostats	X				X					X	
Thermocouple Pyrometers	X						X				

Table III—Load and Deflection Formulas for Bimetal Shapes

$$d = \frac{KTL^2}{t}$$

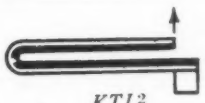
$$p = \frac{ATwt^2}{L}$$

$$p = \frac{Bwt^3d}{L^3}$$

$$d = \frac{KTL^2}{4t}$$

$$p = 4A\frac{Twt^2}{L}$$

$$p = 16B\frac{wt^3d}{L^3}$$



$$d = \frac{KTL^2}{2t}$$

$$p = 2A\frac{Twt^2}{L}$$

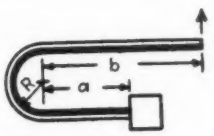
$$p = 4B\frac{wt^3d}{L^3}$$

Spiral or Helix

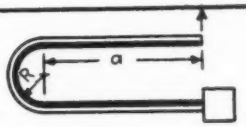
$$\Delta = C\frac{TL}{t}$$

$$M = XTwt^2$$

$$M = Y\frac{wt^3\Delta}{L}$$

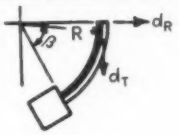


$$d = \frac{KT}{t}(b^2 - a^2 + 4R^2 + 2ab + 2\pi Rb)$$



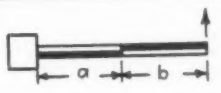
$$d = \frac{2KT}{t}(a^2 + \pi Ra + 2R^2)$$

If $R = O$, $d = \frac{2KTa^2}{t} = \frac{KTL^2}{2t}$



$$d_R = \frac{2KT}{t}R^2(1 - \cos\beta)$$

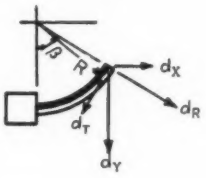
$$d_T = \frac{2KT}{t}R^2(\beta - \sin\beta)$$



Reverse Welded

$$d = \frac{KT}{t}(b^2 - 2ab - a^2)$$

If $b = 2.4a$, $d = 0$

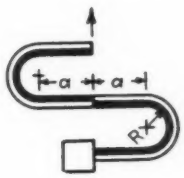


$$d_X = \frac{2KT}{t}R^2(\sin\beta - \beta\cos\beta)$$

$$d_Y = \frac{2KT}{t}R^2(\beta\sin\beta + \cos\beta - 1)$$

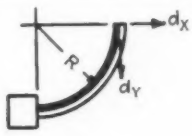
$$d_R = \frac{2KT}{t}R^2(1 - \cos\beta)$$

$$d_T = \frac{2KT}{t}R^2(\beta - \sin\beta)$$



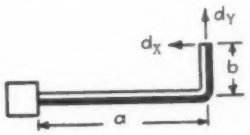
Reverse Welded

$$d = \frac{4KT}{t}(a^2 + \pi Ra + 2R^2)$$



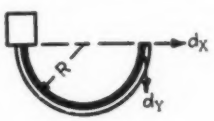
$$d_X = \frac{2KT}{t}R^2$$

$$d_Y = (\pi - 2)\frac{KT}{t}R^2$$



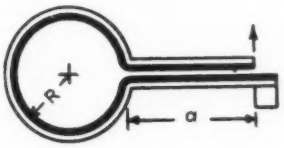
$$d_X = \frac{KT}{t}Lb$$

$$d_Y = \frac{KT}{t}a^2$$

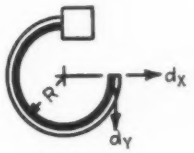


$$d_X = \frac{4KT}{t}R^2$$

$$d_Y = 2\pi\frac{KT}{t}R^2$$

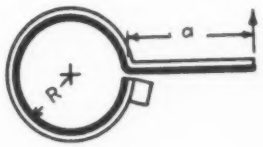


$$d = \frac{2KT}{t}(a^2 + 2\pi Ra + 2\pi R^2)$$

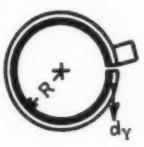


$$d_X = \frac{2KT}{t}R^2$$

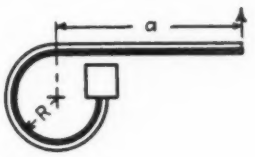
$$d_Y = (3\pi + 2)\frac{KT}{t}R^2$$



$$d = \frac{KT}{t}(a^2 + 4\pi Ra + 4\pi R^2)$$

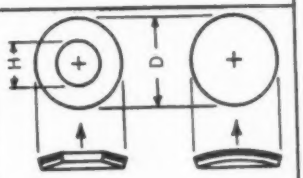


$$d_Y = 4\pi\frac{KT}{t}R^2$$



$$d = \frac{KT}{t}(a^2 + 3\pi Ra + 2R^2)$$

$$d = 1.13\frac{KTL^2}{t}$$



Washer

$$d = \frac{KT}{4t}(D^2 - H^2)$$

Disk

$$d = \frac{KT}{4t}D^2$$

t = thickness, in.
w = width, in.
L = length, in.

d = deflection of free end, in.
p = pull, oz. at free end
M = torque, in oz.-in.
T = temperature change, deg. F.

Δ = angular rotation, deg.
β = angle, radians
θ = change in slope, radians

bimetals is sequence control, where deflection of the bimetal is produced by auxiliary heating. Some relays use bimetal elements. If, for example, a time sequence of electrical operations is wanted, several bimetal strips can be used to open or close circuits. The bimetal strips are heated with wire resistors wound around them or by current passing through them.

Another fairly recent sequence control is the electric circuit breaker. The modern bimetal circuit breaker for domestic or industrial panels is the same size and looks like an ordinary toggle switch. In fact, it may be used as a simple switch. The load current is carried through a short strip of bimetal about $1\frac{1}{2}$ in. long, through a length of copper braid and through a pair of contacts. As current flows through the bimetal it heats the bimetal, causing it to move slowly until it trips a spring loaded latch, breaking the circuit between the contacts. The latch is so calibrated that bimetal motion caused by 100 percent load will never be enough to trip while that caused by 125 percent load (or current) will trip in less than one hour when heated by overload current.

Many circuit breakers use trimetals or graduated resistance metals. A single circuit breaker design may be adapted to several currents by using a trimetal with a different electrical resistance for each current rating. Most bimetals have nearly the same temperature deflection rate and the same I^2R heating product when used at their respective capacities. If a circuit breaker is designed for 15 amp using a trimetal having an electrical resistivity of 440 ohms (sq mil-ft), the same unit can then be used for other ratings from 20 to 50 amp by using trimetal elements whose electrical resistivity runs from 245 to 39 ohms (sq mil-ft).

In Table II are listed industrial and consumer products that use bimetal elements.

Load and Deflection

Bimetal can be formed into many shapes. The picture appearing on page 106 shows a few of these shapes. Load and deflection formulas for common shapes are listed in Table III. These assume that the width of the element is constant. For shapes not shown, the deflection of the element and the force it can exert when heated can be calculated.

The change in curvature of a bimetal with change in temperature is

$$\frac{1}{R_2} - \frac{1}{R_1} = \frac{F}{t}(T_2 - T_1) \qquad (1)$$

where

$\frac{1}{R_1}$ is the original curvature and $\frac{1}{R_2}$ is the final curvature

T_1 and T_2 are the original and final temperatures in deg F

t is thickness in in.

F is flexivity in in. per in. per deg F

For most bimetals, F is $1\frac{1}{2}$ times the difference in the thermal coefficients of linear expansion of the low and the high expanding metals making up the bimetal. The deflection of any element can be found by using Eq (1) and setting up the linear or angular deflection equation for the element in terms of the physical dimensions of the element and then integrating over its length. In practice, cross curvature and method of mounting of the element may have some effect on actual deflections, but these effects are not too important and are not included in the formulas given.

The force a bimetal element can exert is equal to the force that must be applied at a point on the element to produce a deflection equal and opposite to the thermal deflection. As an example, the cantilever element shown in Table III has a thermal deflection of

$$d = \frac{KTL^2}{t}$$

The deflection for a cantilever beam caused by a load P at the end of the beam is $PL^3/3EI$. For a rectangular element $I = Wt^3/12$, so $d = 4PL^3/EWt^3$. Equating deflections and solving for P,

$$P = \frac{KEWt^2T}{4L}$$

Letting $A = 4KE$ and expressing P in ounces instead of pounds, $P = ATWt^2/L$, which agrees with the formula shown in Table III. The load applied by other shapes can be calculated in the same way.

The constants K, A, B, C, X and Y used in the formulas, are listed in Table I for a number of bimetals. For other bimetals these constants may be computed if flexivity and modulus of elasticity are known, from

$K = 0.5F$ $\quad B = 4E$

$C = 126.6K$ $\quad X = 2.94\,KE$

$A = 4KE$ $\quad Y = 0.0232E$

There usually is a time lag involved when a bimetal is immersed in a medium at a higher or lower temperature. The lag depends on the speed with which the bimetal unit moves to a position corresponding to equilibrium temperature. Time of lag is a function of the ordinary laws of heat transfer and may be dependent on mass, surface, electrical characteristics or shape of the bimetal and on the characteristics and velocity of the surrounding medium. With convection heat transfer, response is fast with thin bimetal and a high velocity surrounding medium; with heat transfer by conduction, speed depends on using heavy bimetal with high heat conductivity; and when transfer is by radiation, speed is a function of the area-mass ratio.

Where a long-time lag is desirable as in a time delay relay, the bimetal should be shielded from the heat source. One of the most satisfactory ways of obtaining short time and temperature lags is to heat bimetal strip or part by passing current through it. This gives practically instantaneous response.

In contrast to the time lag involved before the bimetal takes up a deflected position corresponding to equilibrium temperature, there is zero or near zero difference between the actual deflected position of a bimetal unit and its theoretical deflected position at any one temperature. Whatever the instantaneous temperature of the bimetal strip may be, the deflected position corresponds to this instantaneous temperature.

Carefully conducted tests on bimetal coils immersed suddenly in heated oil have shown this lag, if it does exist, to be less than one tenth of a second. Short circuit tests on bimetal circuit breakers have shown it to be less than one half cycle on 60 cycle alternating current.

* * * *

History records many early uses of piping systems but it does not go back far enough to give the time or place of the first use of such tubes. One of the earliest mentioned uses was a crude tile system built into an Egyptian temple some 5,000 years ago. While cast iron pipes were in use in France by the year 1685, the early settlers of the United States did not have the materials or facilities for pipe production. In the 1750's the Colonists were using bored, pine logs for their water carriers. It was not until 1825, when Cornelius Whitehouse invented a method of manufacturing pipe by drawing a strip of hot metal through a die to form a whole length of pipe in one operation, that strong pipe could be made rapidly and economically.

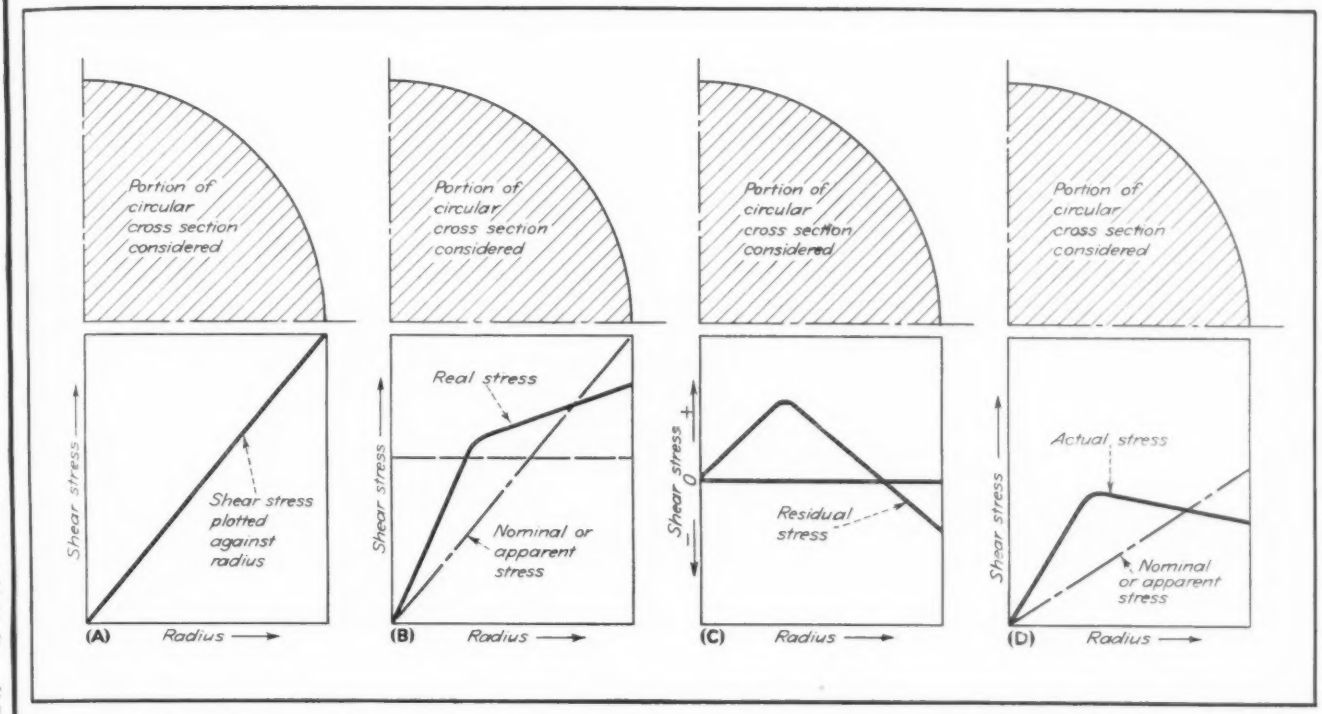


Fig. 1—(A) Normal stress distribution in a circular bar when the maximum stress does not exceed the elastic limit. (B) Actual stress distribution in a circular section bar when the maximum stress does exceed the elastic limit, together with the "apparent" stress required to support the same torque. (C) Residual stress distribution when the torque is removed from a circular section bar after loading to produce the (B) stress distribution. (D) Real and "apparent" stress distribution graphs in a bar of circular cross-section when subsequently loaded to a less extent than occurred during the presetting operation.

Torsion Bar Springs

Basic formulas for stress distribution, energy storage, spring rates and the load capacity. Material selection and heat-treatment.

DONALD BASTOW
Assistant
W. O. Bentley, Consulting Engineer

THE TORSION BAR and the coil spring are different outward forms of spring in which the stressing of the material is quite similar. Although the methods of applying the loads are different, the splined or serrated ends of the torsion bar through which the torque is applied, correspond closely to the "dead" coils at each end of the coil spring. At present the coil spring is by far the more popular form of the two, but there is no fundamental reason for this emphasis. The torsion bar shows definite advantages in some applications. For instance, when applied to vehicle suspensions, unsprung weight is reduced and the twist applied to the vehicle structure by unequal wheel loads can be lessened. The spring weight for a given energy storage is reduced for a given endurance. The torsion bar is sometimes easier to apply, for instance, where there is no convenient abutment for the frame end of a coil spring.

STRESS DISTRIBUTION

For deflections producing skin stresses below the elastic limit the stress in any part of a circular torsion bar is proportional to its distance from the center of the circle. This is represented by the graph, Fig. 1(A), for a circular section.

Presetting is sometimes done as the last operation after shot peening or reeling (an operation producing the same surface condition as shot peening, by rolling with hard steel rolls or wheels), if used, to increase the allowable maximum stress or fatigue life of a torsion bar. Deflection of the bar is carried, during the manufacturing process, to a point where the elastic limit is exceeded in the fibers for some depth into the section. Then stress distribution is indicated diagrammatically by Fig. 1(B). Removal of the applied torque does not then result in return to an unstressed condition, but a stress distribution as shown diagrammatically by Fig. 1(C). Subsequent deflection to an amount less than that given during the presetting process gives a stress distribution as indicated in Fig. 1(D) by the full line. The dotted line indicates the apparent stress that would exist to support the same torque if presetting had not been performed.

ENERGY STORAGE

Consider a round of diameter d in. and length l in. subjected to a torque of T lb inch. The volume is $(\pi/4)(d^2 l \text{ in.}^3)$. Reference to data panel A in Table I shows that the maximum shear stress f_s in psi is

$$f_s = \frac{16T}{\pi d^3} \qquad (1)$$

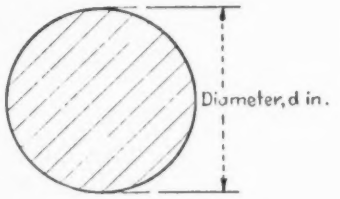
and that the deflection (angle of twist) θ in radians is

$$\theta = \frac{32Tl}{\pi d^4 G} = \frac{2f_s l}{Gd} \qquad (2)$$

The shear modulus G is usually taken as 11.5×10^6 psi for steel. Work done in producing a deflection is $T\theta/2$ within the elastic limit. By substitu-

Table I — Formulas for Torsion Bar Springs

(A) SOLID CIRCULAR SECTION



Section Modulus: $Z_T = \frac{\pi d^3}{16}$

Stress: $f_s = \frac{16WL}{\pi d^3}$ psi

Load, W lb
Effective Lever Length, L in.

Torsional Moment of Inertia:

$$J = \frac{\pi d^4}{32}$$

Angle of Twist: $\theta = \frac{WLl}{JG}$ radians

$$= \frac{2f_s l}{Gd}$$

Torsion Bar Effective Length, l in.
Shear Modulus, G psi

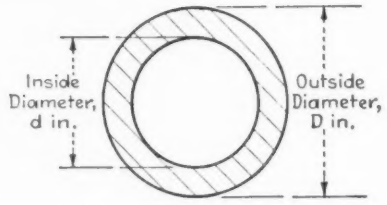
Angle of Twist in Degrees is $57.3\,\theta$

Spring Rate $= \frac{\pi d^4 G}{32l}$ lb-in. per radian

Spring Rate at End of Lever $= \frac{\pi d^4 G}{32lL^2}$ lb per in.

Energy Storage $= \frac{f_s^2}{4G}$ in.-lb per in.^{3}

(B) HOLLOW CIRCULAR SECTION



Section Modulus: $Z_T = \frac{\pi}{16}\left[\frac{D^4 - d^4}{D}\right]$

Stress: $f_s = \frac{16\,WL}{\pi\left[\frac{D^4 - d^4}{D}\right]}$ psi

Load, W lb
Effective Lever Length, L in.

Torsional Moment of Inertia:

$$J = \frac{\pi(D^4 - d^4)}{32}$$

Angle of Twist: $\theta = \frac{WLl}{JG} = \frac{2f_s l}{GD}$ radians

Torsion Bar Effective Length, l in.
Shear Modulus, G psi

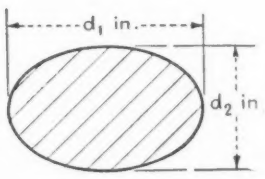
Angle of Twist in Degrees $= 57.3\,\theta$

Spring Rate $= \frac{\pi(D^4 - d^4)G}{32l}$ lb-in. per radian

Spring Rate at End of Lever $= \frac{\pi(D^4 - d^4)G}{32lL^2}$ lb per in.

Energy Storage $= \frac{f_s^2}{4G}\left(\frac{D^2 + d^2}{D^2}\right)$ in.-lb per in.^{3}

(C) ELLIPTICAL SECTION



Section Modulus: $Z_T = \frac{\pi d_1 d_2^2}{16}$

Stress: $f_s = \frac{16WL}{\pi d_1 d_2^2}$ psi

Load, W lb
Effective Lever Length, L in.

Torsional Moment of Inertia:

$$J = \frac{\pi d_1^3 d_2^3}{16(d_1^2 + d_2^2)}$$

Angle or Twist: $\theta = \frac{16WLl(d_1^2 + d_2^2)}{\pi d_1^3 d_2^3 G}$

$$= \frac{f_s l(d_1^2 + d_2^2)}{d_1^2 d_2 G}$$ radians

Torsion Bar Effective Length, l in.
Shear Modulus, G psi

Angle or Twist in Degrees $= 57.3\,\theta$

Spring Rate $= \frac{\pi d_1^3 d_2^3 G}{16l(d_1^2 + d_2^2)}$ lb-in. per radian

Spring Rate at End of Lever $= \frac{\pi d_1^3 d_2^3 G}{16lL^2(d_1^2 + d_2^2)}$ lb per in.

Energy Storage $= \frac{f_s^2}{8G}\left(\frac{d_1^2 + d_2^2}{d_1^2}\right)$ in.-lb per

tion, the work done, $T\theta/2$ is

$$\frac{T\theta}{2} = \left(\frac{\pi d^3 f_s}{16}\right)\left(\frac{2f_s l}{Gd}\right)\left(\frac{1}{2}\right) = \frac{d^2 f_s^2 l}{16G} \quad (3)$$

and the work per unit volume P_v

$$P_v = \left(\frac{\pi d^3 f_s}{16}\right)\left(\frac{2f_s l}{Gd}\right)\left(\frac{1}{2}\right)\left(\frac{4}{\pi d^2 l}\right)$$

$$= \frac{f_s^2}{4G} \text{ in.—lb per cu in.} \quad (4)$$

It can be shown that in the ideal leaf spring the elastic energy stored, assuming circular bending of the spring leaves, is given by the expression $f^2/6E$, where f is the maximum surface stress in psi, tensile or compressive, and E is Young's Modulus, usually taken as 30×10^6 psi for steel. For equal stresses, the ratio of energy storage, torsion bar to leaf spring, is thus 3.91 to 1 for steel.

Robert Schilling in the SAE *Transactions,* 1946, p 367, gives as normal values for energy storage the values shown in Table II. It is interesting to note that these values correspond to the nominal or apparent stresses in Table III, which are obtained by using the formulas of $f_s^2/4G$ and $f^2/6E$ given above.

As the difference between coil and torsion bar springs, for equal stresses, should be affected mainly by the correction factor, the correction factor might be deduced to be of the order of 1.12 to 1.20 in normal practice. This would correspond to a ratio of 7.25 to 11.6 for mean dia to wire diameter.

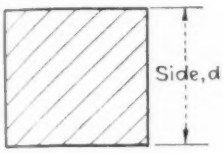
Damping

Damping in a suspension system may be caused by stress hysteresis in the material, friction in the suspension mechanism or springs, or added friction or hydraulic damping. The first of these is too small to provide the damping required, and reliance must therefore be placed on the other sources. (For more extensive information on the subject of hysteresis, see "Elastic Hysteresis in Crankshaft Steels," by Dr. Dorey, *Proceedings* of the Institution of Mechanical Engineers, 1932, Vol 123, p 479.)

Because the static value is higher than the moving figure, friction is bad in a vehicle suspension. Variations in load, plus or minus, up to the static friction values cannot cause movement of the spring; therefore they must be passed on as "shocks" to the object suspended. High static friction in a vehicle suspension gives a bad "boulevard" ride. For most vehicular applica-

Six Types of Cross-sections

) SQUARE SECTION



ion Modulus: $Z_T = 0.2082d^3$

ss: $f_s = \dfrac{WL}{0.2082d^3}$ psi

oad, W lb

ffective Lever Length, L in.

sional Moment of Inertia: $J = 0.1406d^4$

le of Twist:

$$\theta = \frac{WLl}{0.1406d^4G} = \frac{1.482\,f_s l}{Gd} \text{ radians}$$

orsion Bar Effective Length, l in.

hear Modulus, G psi

ngle of Twist in Degrees $= 57.3\,\theta$

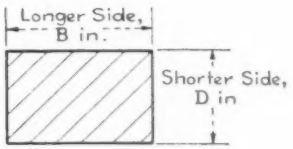
ng Rate $= \dfrac{0.1406d^4G}{l}$ lb-in. per radian

ng Rate at End of Lever

$$= \frac{0.1406d^4G}{lL^2} \text{ lb per in.}$$

gy Storage $= \dfrac{f_s{}^2}{6.48G}$ in.-lb per in.^{3}

(E) RECTANGULAR SECTION



Section Modulus: $Z_T = K_2BD^2$

Values of K_2 from Graph or from St. Venant's Approximation

$$K_2 = \frac{1}{3(1.0+0.6\ D/B)}$$

Stress: $f_s = \dfrac{WL}{K_2BD^2}$ psi (at middle of long sides)

Load, W lb

Effective Lever Length, L in.

Torsional Moment of Inertia:

$$J = K_1\left(\frac{B^3D^3}{B^2+D^2}\right)$$

Values of K_1 from Graph or from Bach's Approximation for Values of $B/D < 6/1$

$$K_1 = \frac{1}{3.645 - 0.06\,B/D} \text{ or } = \text{approx } \frac{16.5}{60-(B/D)}$$

Angle of Twist:

$$\theta = \frac{WLl}{GK_1(B^3D^3)/(B^2+D^2)} = \frac{f_s l}{G}\left(\frac{K_2}{K_1}\right)\frac{B^2+D^2}{B^2D}$$

Torsion Bar Effective Length, l in.

Shear Modulus, G psi

Angle of Twist in Degrees $= 57.3\,\theta$

Spring Rate $= \dfrac{K_1B^3D^3G}{(B^2+D^2)l}$, lb-in. per radian

Spring Rate at End of Lever

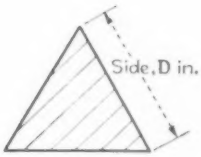
$$= \frac{K_1B^3D^3G}{L^2(B^2+D^2)l}, \text{ lb per in.}$$

Energy Storage

$$= \left(\frac{f_s{}^2}{G}\right)\frac{60B^2D + 60D^3 - B^3 - BD^2}{297B^2D + 356.4BD^2 + 106.92D^3}$$

in.-lb per in.^{3} (approx)

(F) EQUILATERAL TRIANGULAR SECTION



Section Modulus: $Z_T = 0.05D^3 = \dfrac{D^3}{20}$

Stress: $f_s = \dfrac{20WL}{D^3}$ psi

Load, W lb

Effective Lever Length, L in.

Torsional Moment of Inertia:

$$J = \frac{\sqrt{3}}{80}D^4 = 0.02164D^4$$

Angle of Twist: $\theta = \dfrac{WLl}{0.02164D^4G} = \dfrac{46.2WLl}{D^4G} = \dfrac{2.31f_s l}{GD}$ radians

Torsion Bar Effective Length, l in.

Shear Modulus, G psi

Angle of Twist in Degrees $= 57.3\,\theta$

Spring Rate $= \dfrac{GD^4}{46.2l}$ lb-in. per radian

Spring Rate at End of Lever

$$= \frac{GD^4}{46.2lL^2} \text{ lb per in.}$$

Energy Storage $= \dfrac{f_s{}^2}{7.5G}$ in.-lb per in.^{3}

tions damping, generally hydraulic, is necessary to obtain the best results.

Damping is always a compromise. There are many different methods of applying damping, as evidenced by hydraulic damper performance curves. Plain, equal up-and-down damping without much velocity build-up is the nearest equivalent to friction damping but without the static friction. The sprung-body, inertia-controlled damping represents the other extreme.

Damping should always vary with the use; and, ideally, with the user. No hard and fast rules can be given. The type of spring, body to be sprung and type of loading must be weighed. Absence of static friction in the torsion bar itself, as compared with the leaf spring, does allow a better ride to be obtained. But, it also compels reliance upon an outside source for damping spring action.

Types of Torsion Bars

Variations are possible both in the shape of the cross section of the torsion bar and in the use of simple, "double back," or "in parallel" varieties. Solid or hollow round, solid square, rectangular, triangular or elliptical cross sections are covered by formulas given in Table I.

In general, two methods of "doubling back" have been used. The bar and tube method of Vauxhall Motors Ltd. (English member of General Motors) used in their car front suspension is shown by Fig. 2 and Fig. 3 (a), (b). In this construction part of the required deflec-

Table II—Energy Storage

Form of Spring	Energy Storage, in.-lb per lb of spring
Leaf	300–450
Helical Round Wire Coil	700–1,100
Torsion Bar	1,000–1,500
Volute	500–1,000
Rubber Spring in Shear	2,000–4,000

Table III—Computed Nominal or Apparent Stresses

Form of Spring	Max. Stress, psi
Leaf	124,000–151,000
Helical Round Wire Coil	95,000–125,000
Torsion Bar	114,000–140,000

tion is obtained in the solid torsion bar and part in the encircling tube that takes the torque back to the desired anchorage point. The suspension action is modified by the mechanism described by Fig. 3 (A), (B). The coil spring shown softens the spring action in mid range but stiffens it at either extreme. Second construction is the parallel torsion bar method used in the German Panzer Mark VI tank and also in the French Dyna-Panhard car valve return spring. This latter is the simpler form of the two, Fig. 4 (A), (B), and consists of two parallel torsion bars. These are coupled together at one end by a connecting bar. Torque is applied at the opposite end of the first bar, while the end of the second bar is anchored. The connecting bar transfers torque and angular deflection from one torsion bar to the other at the expense of slight bending in both torsion bars.

In the German Panzer Mark VI the only difference was that the connecting bar was pivoted to the tank hull. The other ends of the two torsion bars were respectively anchored and connected to the lever feeding in the torque caused by the load on the appropriate wheel. In the Dyna-Panhard the connecting bar is free. This latter design is ingenious also in that the combination of the two parallel torsion bars serves as a spring for both valves; an arrangement possible and justifiable only with the smallest amount of overlap usual between internal combustion engine inlet and exhaust valves.

The arrangement used in the German KdF car is another compound design. Instead of having the torsion bars in series, they are in parallel. A number of square or rectangular section bars are nested together and operated at one end by a lever connected to the wheel and anchored at the other end. Again, some slight bending is imposed on the torsion bar, but it is not serious in its effects as compared with stresses caused by the torque. This can be demonstrated by an example.

Compound Bar Calculations

Assume the nest consists of four torsion bars; that the sprung wheel load is 700 lb, and that the lever arm is 16 in. long, and that the normal stress is to be limited to 70,000 psi. The total torque is

$$16 \times 700 = 11{,}200 \text{ lb-in.}$$

which implies 2,800 lb-in. per bar, and reference to the formulas in Table III shows that where f_s equals stress in psi, T equals torque in in-lb and the sides are d in. wide.

$$f_s = \frac{T}{0.2082 d^3}$$

from which

$$d^3 = \frac{2{,}800}{70{,}000 \times 0.2082} = 0.1922$$

and that therefore d equals 0.576 in. The center of each bar is therefore 0.4075 in. from the rotation center. If we assume a normal deflection of 7 in., then 7/16 equals 0.4375 radians, and

$$0.4375 = \frac{2{,}800 \times l}{0.1406 \times 0.576^4 \times 11.5 \times 10^6},$$

and $l = 0.4375 \times 0.1406 \times 0.576^4 \times 11.5 \times 10^6 = 28$ in.

The deflection of the end of each bar of the nest is 0.1783 in. at 45 deg to the sides of the square, or 0.126 in. perpendicular to each side. Regarding each bar as anchored at each end and equivalent therefore to two cantilevers:

$$\frac{0.126}{2} = 0.063 = \frac{Wl^3}{3EI}$$

where W is the load in lb required to produce the deflection in question, and therefore

$$W = \frac{0.063 \times 3 \times 30 \times 10^6 \times 0.1108}{12 \times \binom{28}{2}}$$

$$= 19.1 \text{ lb}$$

Now

$$Z = \frac{0.1922}{6}$$

for bending, as Z_B equals $d^3/6$ and, from above, d^3 equals 0.1922. The bending moment is 19.1 $\times$ 14, and the bending stress is

$$\frac{19.1 \times 14 \times 6}{0.1922} = 8{,}350 \text{ psi}$$

or about 12 percent of the shear stress caused by torsion.

In dealing with bars in series, the main point to remember is that they are all subjected to the same torque, and the total deflection is obtained by taking the arithmetic sum of the individual ones. For bars in parallel it is the angular deflection that is the same for each bar; and the torques contributed by each are then added up to give the total torque.

Selecting the Materials

The factors affecting choice of a material are its elastic and fatigue limits, its shear modulus, its specific gravity and its cost. For steel, an energy storage of 1,500 in-lb per lb implies a maximum stress of 140,000 lb per sq inch. Steel is practically the universal material for torsion bars (neglecting for the moment the possibility of rubber achieving much greater popularity). Presumably this is because of its high energy storage and its cheapness per pound. Aluminum alloy, for instance, at a stress of 27,000 psi, with a shear modulus of 3.7 x 10^6 psi and a specific gravity of 2.8, has an energy storage of 480 in-lb per pound. The stress quoted is little more than a guess, as the author has no experience at all in the use of such a material and is not aware of any endurance test results that would justify such a stress. Even so, the energy storage is only between 33 percent and 50 percent of that of steel, per pound, and cost per pound of aluminum is certainly greater.

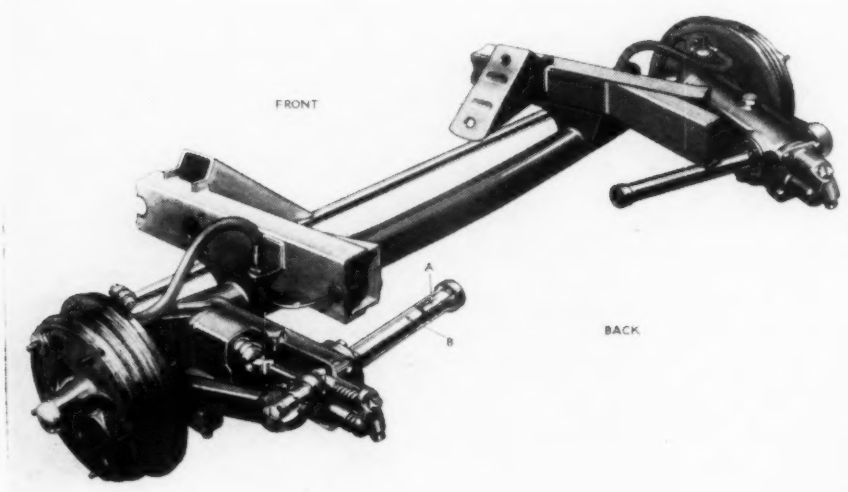


Fig. 2—Bar A and tube B in the phantom view show a proved method of "doubling back" to shorten a torsion bar spring. The 1946 Vauxhall front springing differs from the 1938 design (shown) only by a modification of the oil seal.

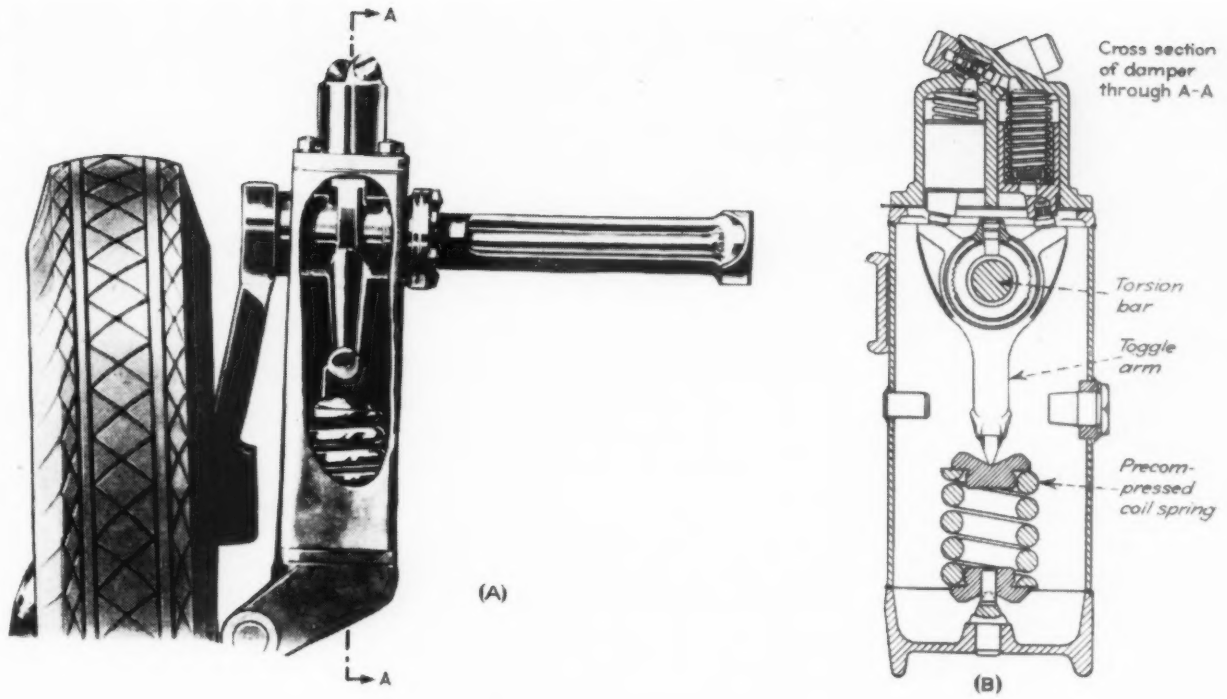


Fig. 3—Stiff precompressed coil spring modifies action of the torsion members shown in Fig. 2. (A) Under normal load the axes of coil spring and toggle lever are in line. (B) When torsion members are twisted, which moves the spring and toggle lever out of line, the precompressed spring exerts a twisting effect of its own, thus changing the load on the torsion members.

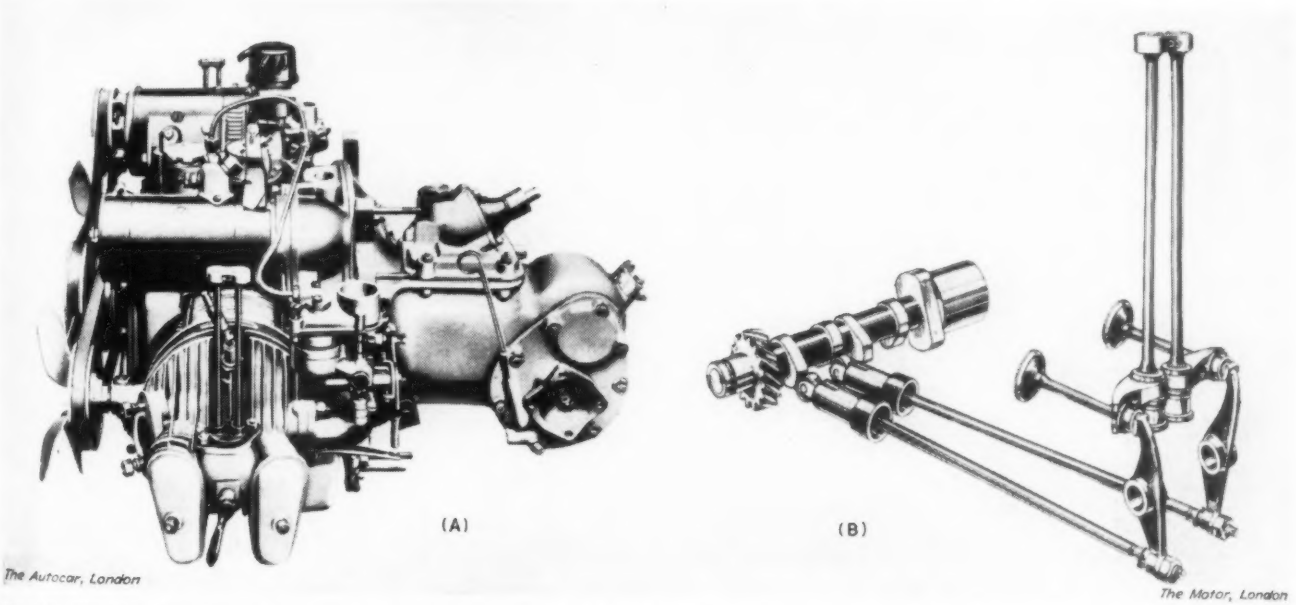


Fig. 4—Torsion bar return valve springing of the aircooled, 24 hp. Dyna-Panhard car. (A) The springs are not subjected to heat stresses because they are outside the cylinder head. (B) Bars work as a unit, interacting through top cross-link.

Another considerable inducement to the use of steel is the wealth of experience available on its use, and the resulting background of knowledge of allowable stresses for different applications. Corresponding knowledge of other materials would have to be acquired, obviously at fairly considerable expense. On the face of it, this test expense does not seem to be justified except in applications for which steel is unsuitable, such as under the highly corrosive conditions.

For highly stressed applications silico-manganese steel is the practically universal choice. Both carbon spring steel and chrome-vanadium steel have been used, the latter fairly extensively in Britain for both torsion bars and coil springs. It is more expensive than silico-manganese steel, and experience does not indicate that this extra expense is justified by the results. Chrome-vanadium steel is considered to be more sensitive to surface faults and flaws than silico-manganese steel.

Heat-Treatment

In heat-treatment the main thing is to avoid surface decarburization. For silico-manganese, at least, this means either avoiding temperatures above 950 C or using a reducing atmosphere furnace. Some precautions against distortion in quenching are desirable; a vertical quench alone does

not seem to be enough to prevent distortion. Avoid straightening after tempering. If bending does occur in heat-treatment, as it almost certainly will to some extent, it is better to allow latitude for this in the design of the associated mechanism.

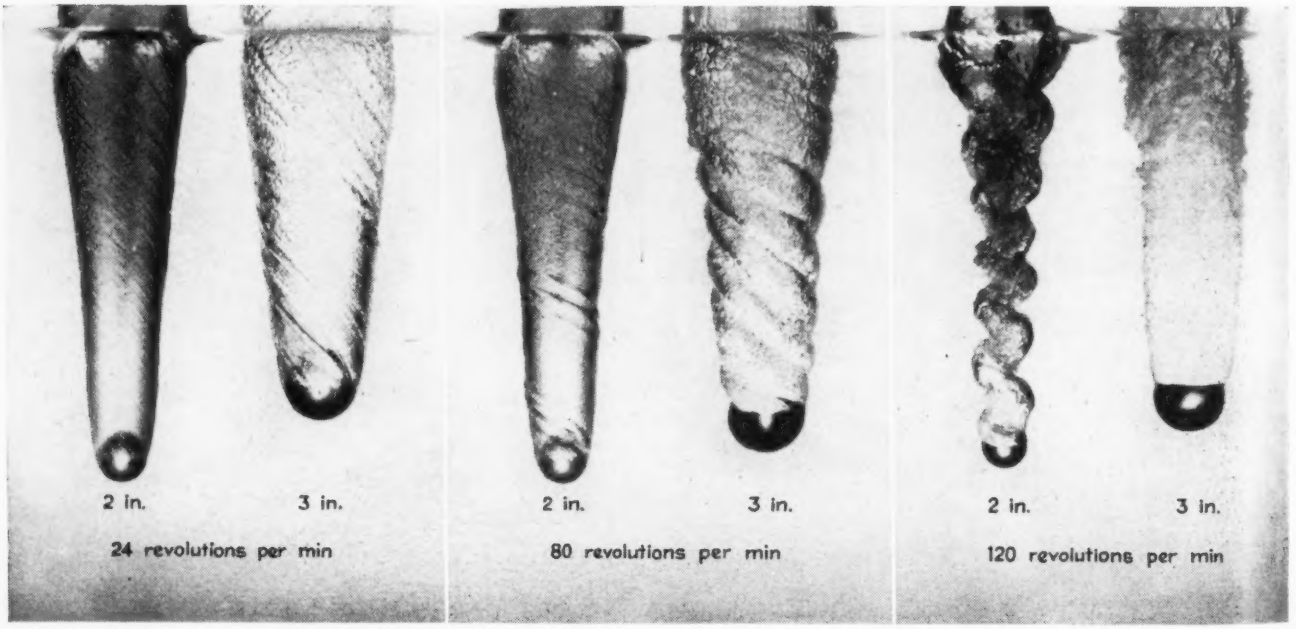
Shot peening or reeling, and presetting, carried out in that order, are both well worth while in increasing either endurance or, alternatively, permissible range. Presetting has already been referred to in a description of its effect on the stress distribution and intensity in the torsion bar (see "Design for Torsion Bar Springs Used in M-18 Tank Destroyer," PRODUCT ENGINEERING, June 1945, p 392). Reference to the diagrams of Fig. 1 will show that presetting is of benefit to the torsion bar by reducing the maximum stress from the surface of the bar to its interior. As might be expected from further study of the diagrams, the best results are obtained if the stress distribution curve is of a given form; that is, if the amount of preset is specified rather than the overload torque that is to be applied. As an example, in one instance the amount of preset recommended was 15 deg., the bar in question being approximately 0.9 in. dia and 49 in. long.

Shot blasting is also believed by many to be effective by removing the point of maximum stress from the surface to the interior of the material. A fuller discussion of this may be found in a paper by J. O. Almen, "Shot Blasting to Increase Fatigue Resistance," SAE *Transactions*, 1943, pp 248-268. It is desirable to specify size of shot, maximum percentage of broken shot allowed, weight of shot impinging on each square inch of surface, and shot velocity (or the equivalent air pressure, when the shot is propelled by air jet). A typical specification would call for 1.5 lb. of 0.051 in. shot per sq in. and 30 psi air pressure.

Usually surface protection of the torsion bar against corrosion is important. Both cadmium plating immediately after shot peening (to take advantage of the chemically cleaned surface left by that operation, thus avoiding a possibly harmful cleaning bath), and stove enamelling, with a baking temperature restricted to 150-200 C, have been used with satisfactory results. Stove enamelling is cheaper.

EDITOR'S NOTE—A second article on the installation of torsion bar springs and the effect of changing the dimensions will appear in an early issue.

Spinning Balls in Water—One Step in Hydrodynamic Research



Official U.S. Navy Photograph

BALLS OF VARIOUS SIZES spinning at different speeds in water are supplying much fundamental information about design of submerged bodies. In a special machine, steel balls are set to spinning at known speeds; then plunged into a tank of water. Wake form is stopped and recorded by photographing at 500,000th of a second.

This is one step in extensive experiments conducted at the Naval Ordnance Test Station, Inyokern, Cal. Various body shapes are being tested with special emphasis on transition effects between different mediums.

It is hoped some relations can be found from these investigations for predicting full-scale operation from model test data. This is particularly difficult since it is hard to scale down liquid action to model size.

Other attempts to correlate model test data with full-scale object performance is being done with torpedo tests. Contemplated designs are built to scale and tested in a glass-walled tank. Models can be released at various angles to the water and the crossbow launcher can be set to give different initial velocities. High speed motion picture camera records the complete run of the missile.

Designs that show promise are built to full scale and are tested from the variable angle launcher located at Morris Dam. This launcher simulates any launching condition that can be encountered by high speed attack airplanes. Missiles can be fired with increasing force until they break upon impact with water. Information gained by these tests will aid in structural design of underwater missiles, as well as underwater body shape. Comparison of results may lead to accurate prediction from models.

Fluid Pressure Drop Losses Through Smooth Straight Tubing

Pressure drop formulas for laminar and turbulent flow. Chart and nomograph to simplify pressure-drop calculations. Test results verifying method.

DOMENIC A. DI TIRRO
Staff Engineer, Development & Testing
The Parker Appliance Company

PROPER DESIGN of hydraulic and fluid handling systems implies an optimum balance between the size of the power generators and the physical systems which routes the fluid. Making pumps "big enough," or lines and valves "generously sized," leaves the door open to unnecessary weight and cost sacrifices.

Frequently, loss calculations for lines are slighted because straight tubing runs account for less fluid pressure loss percentage-wise than valves and other auxiliaries.

Yet in fuel systems where operating pressure is low, or in aircraft hydraulic systems, where a mile or more of circuit tubing may be used, line losses can be a large percentage of total system loss.

In these systems, then, straight tube losses must be accurately calculated to obtain line sizes that result in the most economical application of power.

The following method, developed into a chart and nomograph, simplifies pressure drop loss calculations for straight smooth tubing.

FORMULAS FOR PRESSURE DROP

Pressure drop for a fluid flowing through a straight filled tube (no vapor) is dependent on tube size, length, surface condition of inside of tube, and the viscosity, specific gravity and velocity of the fluid. Pressure has little effect on pressure drop except as it affects fluid density; temperature also has little effect except as it effects viscosity and density.

There are two conditions of liquid flow in a filled tube: laminar or undisturbed at relatively low fluid velocities, and turbulent or disturbed flow at higher fluid velocities. For any one system, the transition point from laminar to turbulent flow, as fluid velocities increase, is located in the flow region defined by the range of Reynolds numbers from 1,500 to 3,000. This condition applies to any tube since the Reynolds number is a nondimensional quantity expressed as

$$R = \frac{d\,v\,\rho}{\mu}$$

where

d = tube dia, ft
v = fluid velocity, ft per sec
ρ = fluid density, lb per cu ft
μ = fluid viscosity, lb per ft-sec

With quantities expressed in a more usable set of units, the foregoing becomes:

$$R = 3159.2\,\frac{Q}{\mu\,d} \qquad (1)$$

where

Q = fluid flow, gal per min
μ = kinematic viscosity, centistokes
d = tube dia, in.

The initial step in calculating friction loss in any one tube, then, is to get the Reynolds number R. From this the friction factor, f, can be determined from

$$f = \frac{64}{R} \text{ for laminar or smooth flow} \qquad (2)$$

$$f = \frac{0.3164}{R^{0.25}} \text{ for turbulent or disturbed flow} \qquad (3)$$

The foregoing equations have been plotted on the logarithmic chart, shown in Fig. 1, which may be used to get fluid friction directly if tube size and fluid characteristics are known. Directions for use are given on the chart. The curve giving the largest friction factor should be used in design.

Note that the slope of all Reynolds number curves are the same; if other fluids are used they can be added to the chart by simply plotting any one point to establish curve location.

The Reynolds number curves for the tube sizes shown in Fig. 1 were constructed for a given oil at a given viscosity (AN-VV-0-366a at 100 F). Only one point is needed to plot each curve, since as mentioned before, the slopes of all are the same. This plot point is gotten by solving equation, $R = 3159.2 \times Q/\mu d$, using the tube size in question, an assumed flow Q, and the kinematic viscosity μ, for the given oil. Values for R and Q establish a point on the desired Reynolds number curve.

The chart can be used to determine friction factors for other tube sizes, flows and fluid characteristics by: (1) Plotting the Reynolds number curves for each one, and (2) projecting up from the point on the Reynolds number curve, corresponding to the fluid flow through the tube, to the friction factor curve.

The friction factor obtained from Fig. 1 may then be used to determine pressure drop for one foot of smooth tube by using the following equation:

$$P = 0.013475\,\frac{\phi f Q^2}{d^5} \qquad (4)$$

where

ϕ = fluid specific gravity
f = friction factor (Fig. 1)
Q = fluid flow, gal per min
d = inside dia of tube, in.

Again, to simplify calculations, the nomograph shown in Fig. 2 has been constructed, and may be used to solve for any one of the variables in Eq (4) if the remaining four are known. Directions for using the nomograph are given on the chart.

The formula (4) on which the nomograph is based is of particular interest since it covers both turbulent and laminar flow in a single equation. This greatly simplifies calculations over other hydrodynamic formulas, which require that the condition of flow be initially determined, and a suitable expression be used involving decimal exponents.

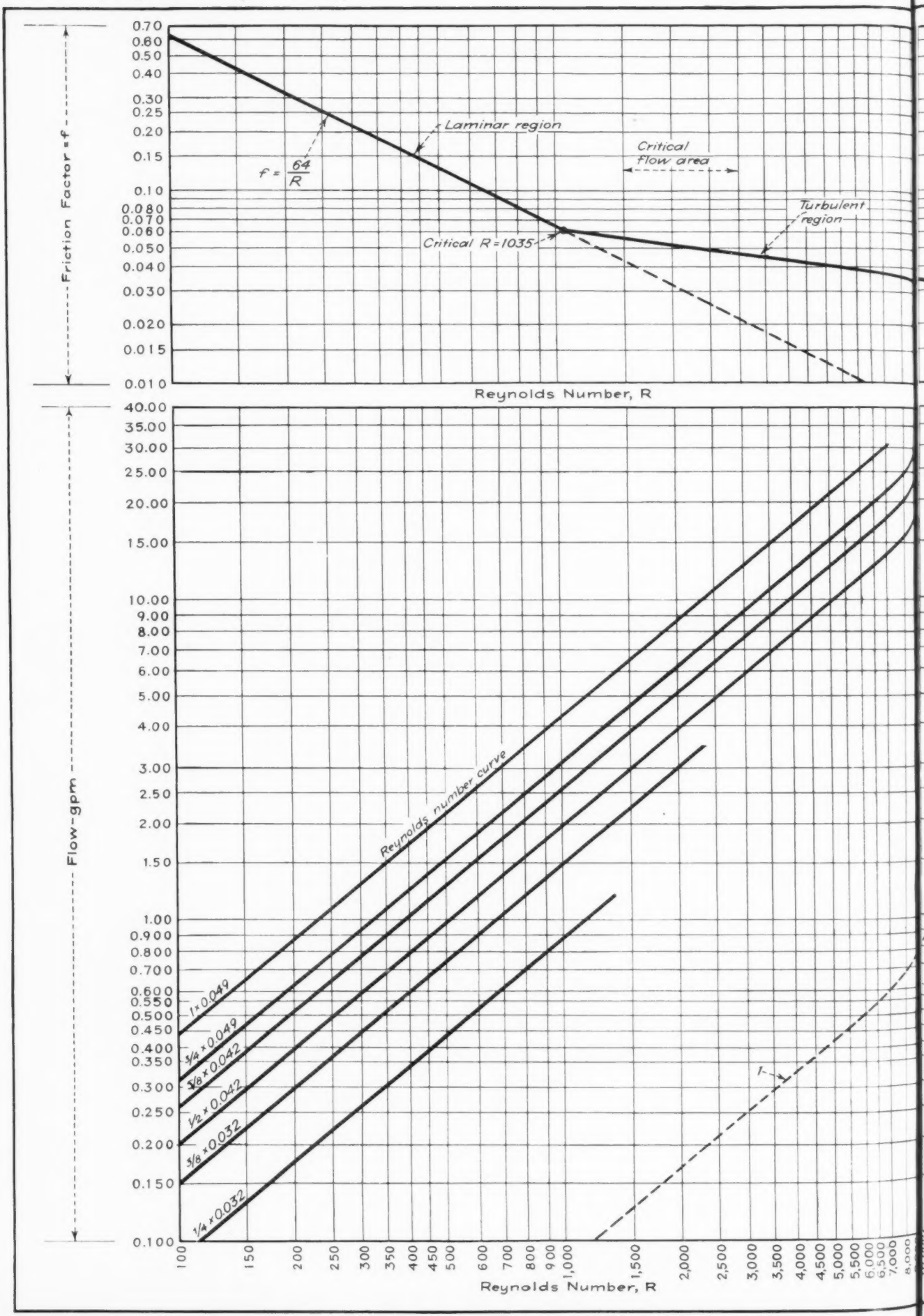
The accuracy of calculated pressure drop has been checked against actual test results for typical fluids (Stoddard's Solvent and aircraft hydraulic oil) so as to cover the extreme limits of laminar and turbulent flow as well as the transition region.

Testing was completed on special pressure test equipment, which was developed by Parker working with The National Bureau of Standards. The maximum deviation of calculated pressure drops from actual test results was 5 percent, with the average considerably closer.

In Fig. 3 is shown a typical chart comparing test and calculated results.

(*continued on page* 118)

Pressure Drop Losses (continued)



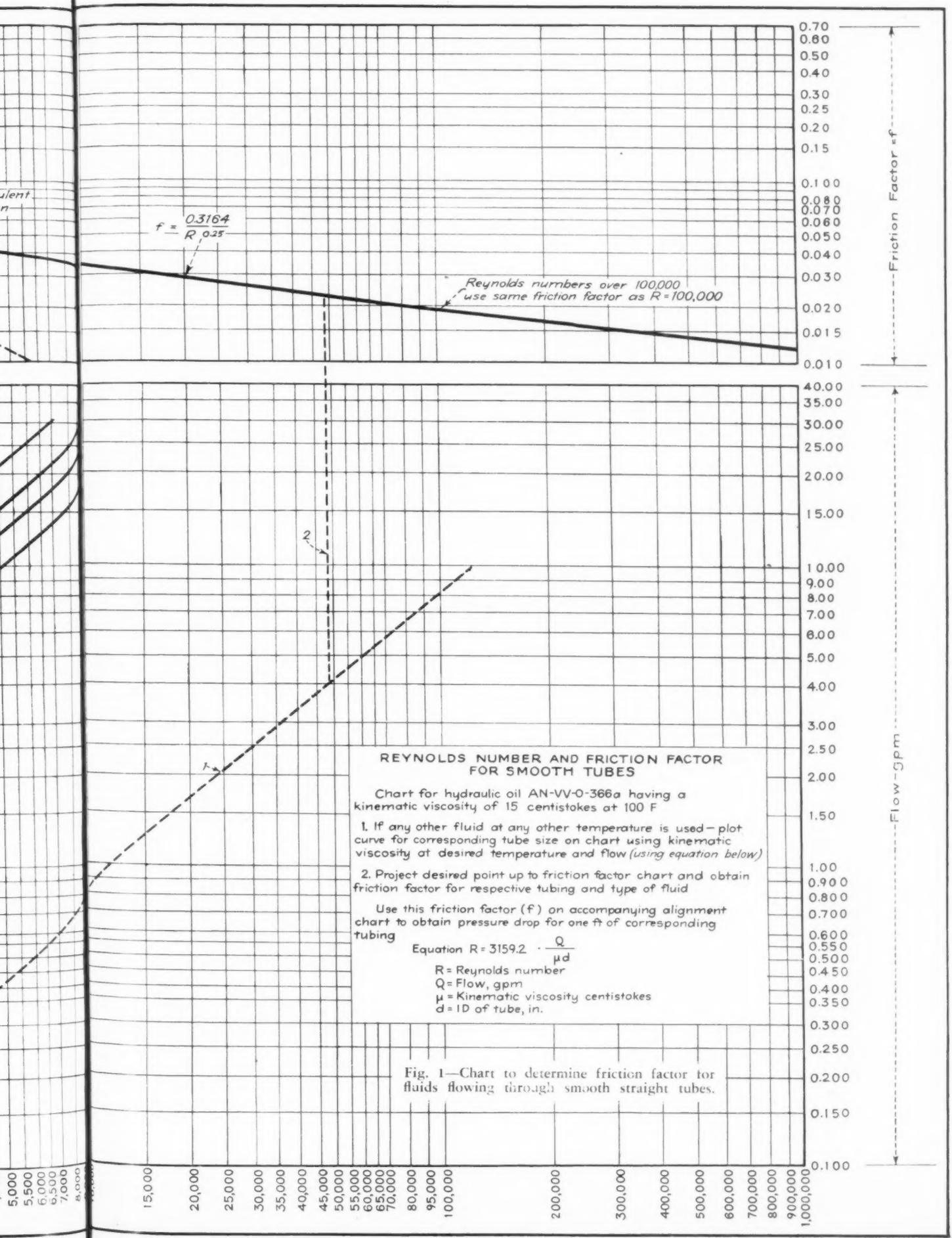


Fig. 1—Chart to determine friction factor for fluids flowing through smooth straight tubes.

(continued on page 120)

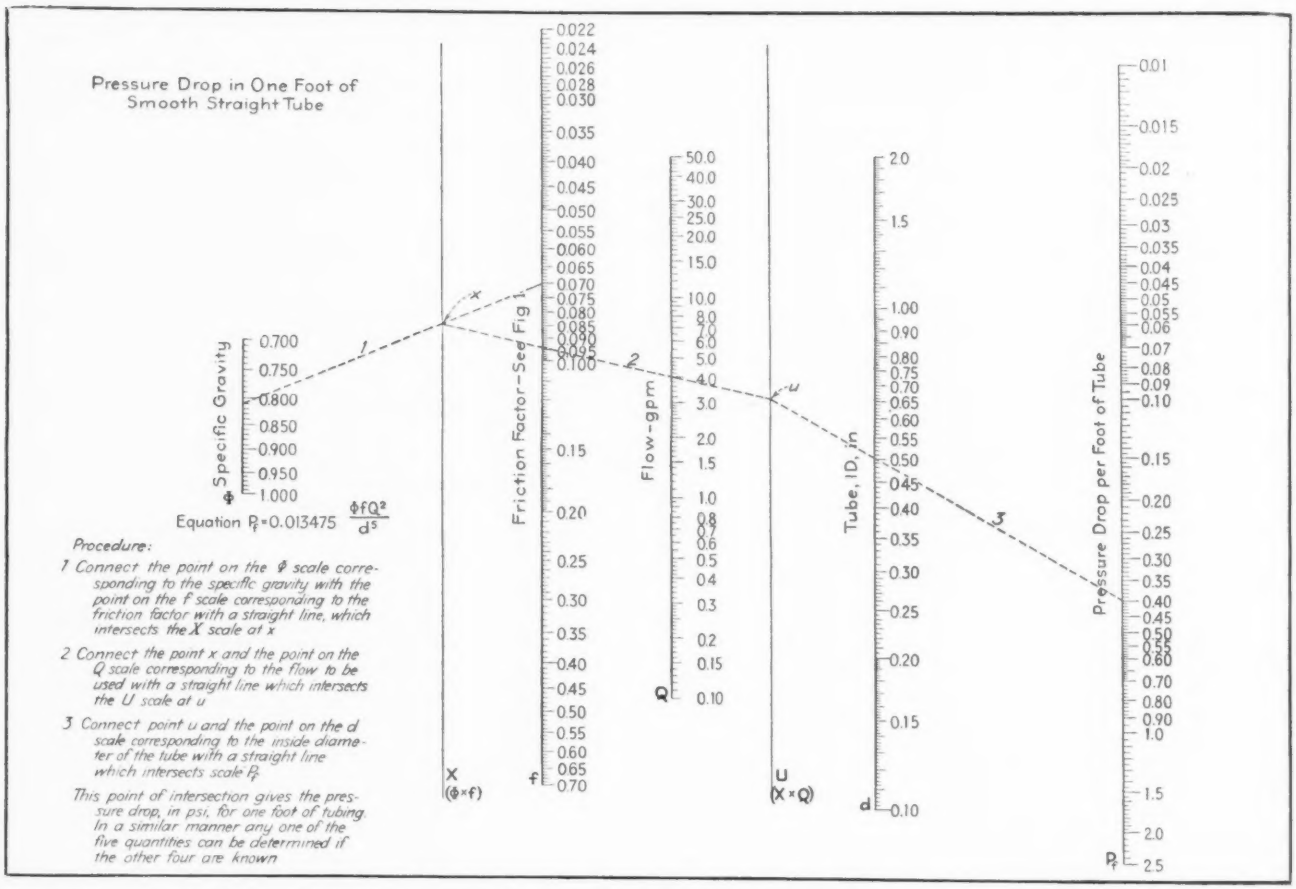

Pressure Drop in One Foot of Smooth Straight Tube
Specific Gravity
Friction Factor - See Fig 1
Flow - gpm
Tube, ID, in
Pressure Drop per Foot of Tube
Equation $P_f = 0.013475 \frac{\phi f Q^2}{d^5}$
Procedure:
1 Connect the point on the ϕ scale corresponding to the specific gravity with the point on the f scale corresponding to the friction factor with a straight line, which intersects the X scale at x
2 Connect the point x and the point on the Q scale corresponding to the flow to be used with a straight line which intersects the U scale at u
3 Connect point u and the point on the d scale corresponding to the inside diameter of the tube with a straight line which intersects scale P_f
This point of intersection gives the pressure drop, in psi, for one foot of tubing. In a similar manner any one of the five quantities can be determined if the other four are known

Fig. 2—Nomograph chart to determine pressure drop loss for fluids flowing through one foot section of smooth straight tubing.

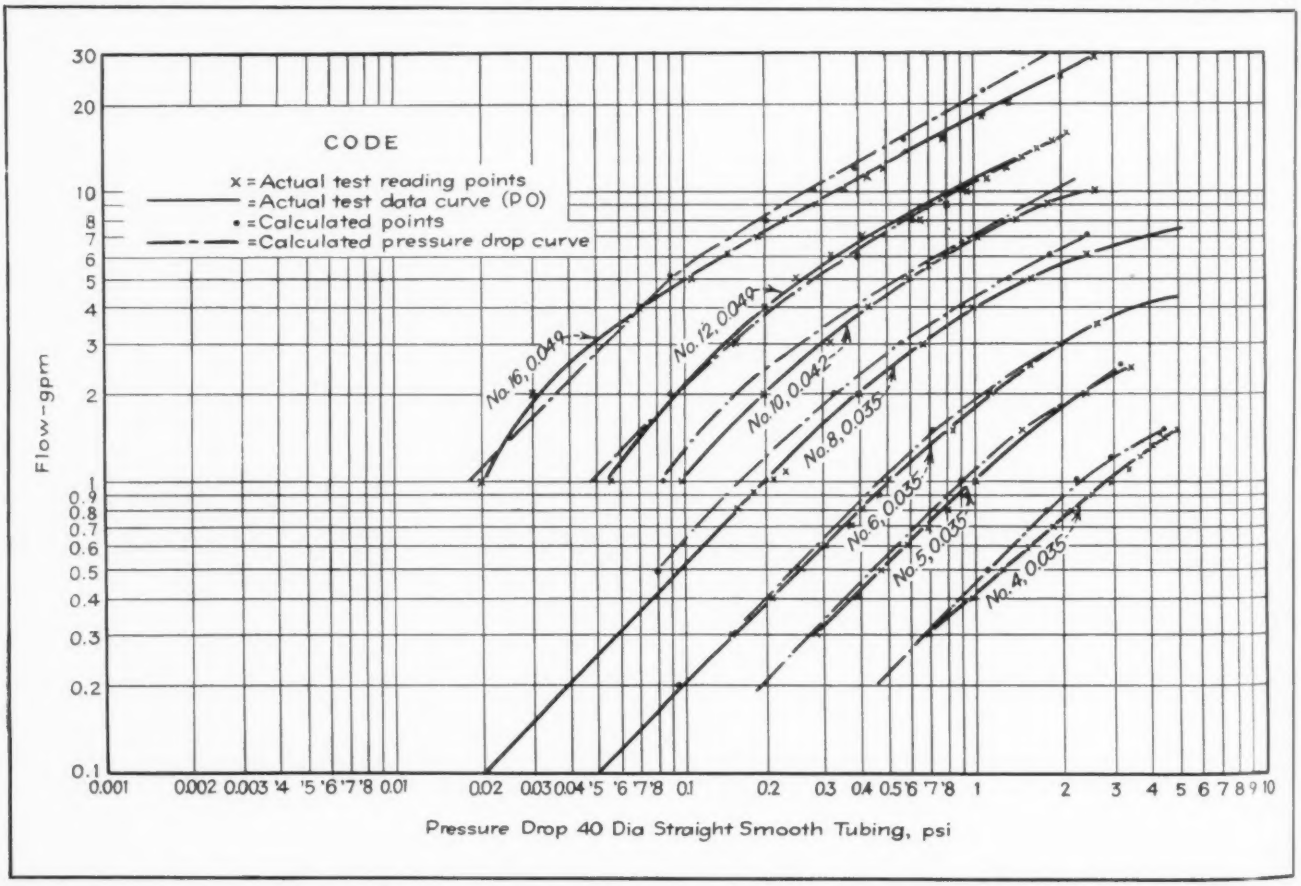


Fig. 3—Chart showing correlation between nomograph calculati ons and experimental results for pressure drop of hydraulic oil flowing through 40 diameters of straight tubing, ¼ to 1 in. sizes. A s shown, agreement between observed and calculated values is good.

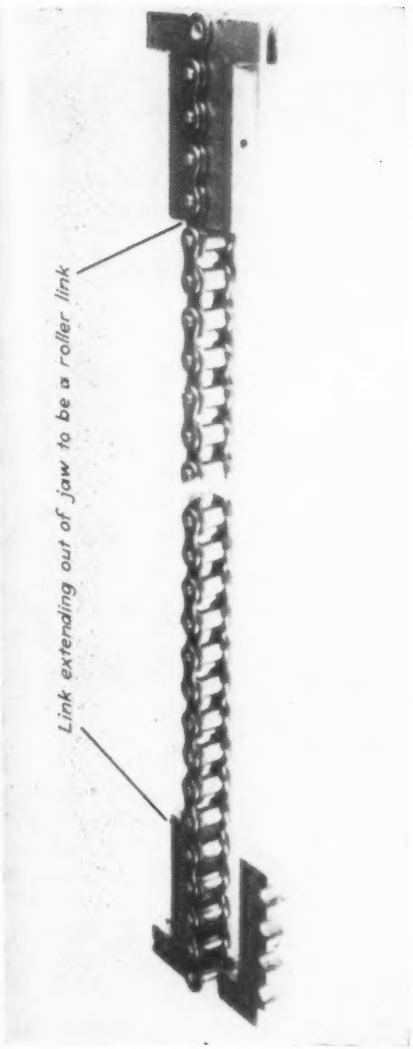
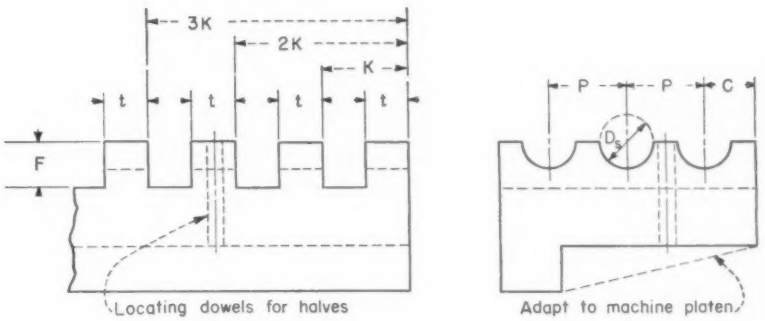


Table I—Dimensions of Jaws for Different Chain Sizes



Chain		Dimension, In.					
A.S.A. No.	Pitch x Width, In.	t	K	C	P	D_s*	F
25	1/4 x 1/8	0.110	0.252	5/32	0.250	0.134	3/16
35	3/8 x 3/16	0.168	0.399	1/4	0.375	0.204	1/4
41	1/2 x 1/4	0.227	not made in mult.	5/16	0.500	0.312	5/16
40	1/2 x 5/16	0.284	0.566	5/16	0.500	0.317	5/16
50	5/8 x 3/8	0.343	0.713	13/32	0.625	0.405	3/8
60	3/4 x 1/2	0.459	0.897	1/2	0.750	0.474	7/16
80	1 x 5/8	0.575	1.153	21/32	1.000	0.631	9/16
100	1-1/4 x 3/4	0.692	1.408	27/32	1.250	0.757	11/16
120	1-1/2 x 1	0.924	1.789	1-1/32	1.500	0.882	13/16
140	1-3/4 x 1	0.924	1.924	1-7/32	1.750	1.008	15/16
160	2 x 1-1/4	1.156	2.305	1-13/32	2.000	1.134	1-1/16
180	2-1/4 x 1-13/32	1.301	2.592	1-1/2	2.250	1.416	1-3/16
200	2-1/2 x 1-1/2	1.389	2.817	1-11/16	2.500	1.574	1-5/16
240	3 x 1-7/8	1.738	3.458	2	3.000	1.887	1-9/16

*This dimension is minimum, with acceptable plus limit = 0.01 D_s + 0.005 in.

Tensile and Elasticity Testing Of Steel Roller Chain

Design of grip jaws and procedure for testing standard steel roller chain as recommended by the Association of Roller and Silent Chain Manufacturers.

TENSILE TESTING of steel roller chain is a destructive test used for the purpose of determining the ultimate tensile or breaking strength of a given specimen. In addition to such testing, it is sometimes desirable to know the elasticity or ratio of elongation to applied load.

For either test, if true results are to be obtained, it is important that the chain specimen be properly mounted and uniformly loaded in the testing machine. In addition, tensile test specimens must be at least eleven pitches and 15 in. long; at least two full pitches (3 rollers in each strand) must be gripped by the jaws; and all loading is to be through the chain rollers. Gripping of the chain sideplates or misalignment of the chain with the line of pull will not give accurate data. Elasticity tests are to be treated the same as for ultimate tensile strength tests except the specimen should be long enough to permit making elasticity measurements over a four foot length of chain.

The speed of testing machine crosshead should not exceed the response characteristics of the recording or indicating mechanism of the machine and should never exceed 0.5 in. per min. Results used for comparative purposes are to be based on at least three tests of chains of equal length.

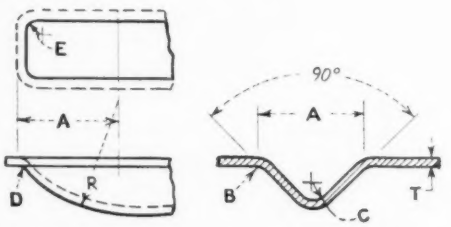
The method of gripping the test specimen in the grip-jaws is shown above. Design information and dimensions of jaws for gripping the different sizes of ASA standard steel roller chain are given in Table I. Jaws should be made of medium carbon alloy steel, heat-treated and drawn for 30 to 40 C Rockwell. Jaw length may be longer than given in Table I. It is important that each pair of jaws be securely held together during test.

Navy Aeronautical Specification C-65d (12-27-40) on "Control Chains" will be satisfied by this data and method of tensile testing.

Metal Stamping Desig

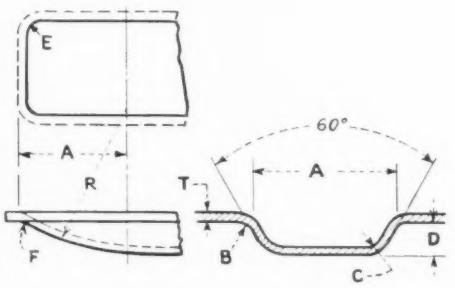
Stampings are made by pressworking sheet material to change its shape and can be divided into two general classifications: (1) Material formed without being cut bending, forming, drawing and coining; and (2) ma

BEADS



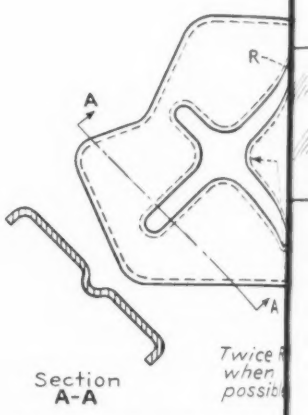
A	B Radius	C Radius	D Radius	E Radius
0.25	T	3T	3T	2T
0.38	T	3T	3T	2T
0.50	T	3T	3T	3T
0.62	3T	5T	3T	3T
0.75	4T	6T	3T	4T
1.00	4T	6T	3T	4T

Maximum radius as determined by "T," and multiples of "T," is not to exceed 0.25 of an inch



A	B Radius	C Radius	D	E Radius	F Radius
1.00	2T	3T	0.25	5T	3T
1.50	2T	3T	0.25	5T	3T

Maximum radius as determined by "T," and multiples of "T," is not to exceed 0.19 of an inch

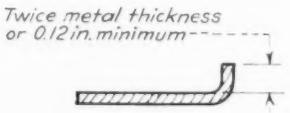


BEADS OF THIS TYPE SHOU FORMED IN SAME DIRECT OUTER FLANGES TO FACIL DIE CONSTRUCTION

Twice R when possibl

STRENGTHENING BEADS FOR FLAT SURFACES AND ANGULAR OR CURVED SURFACES

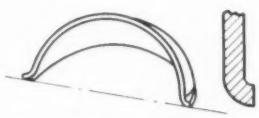
FLANGES



OUTSIDE AND HOLE FLANGE DIMENSIONS

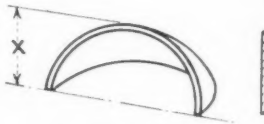
To facilitate trimming, maximum flange should be twice metal thickness

PREFERRED



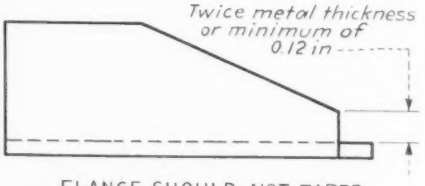
Flange shape when a sharp edge is not objectionable

PERMISSIBLE

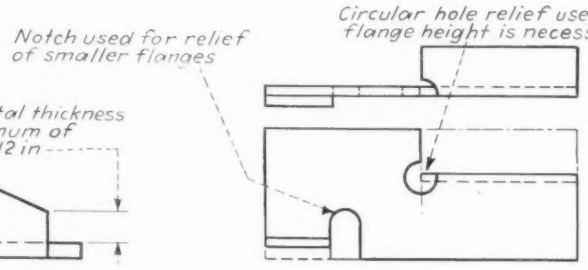


Absence of flange caus expensive trim if X is maintained

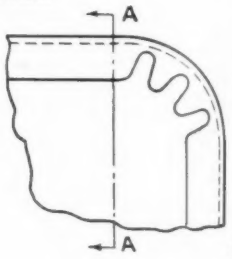
NOT RECOMMENDED



FLANGE SHOULD NOT TAPER TO METAL FACE



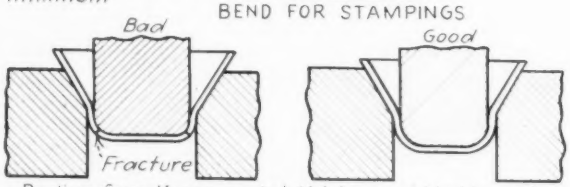
PARTIAL FLANGES IN HIGHLY STRESSED PARTS SHOULD BE RELIEVED BY NOTCH OR HOLE



A HEMMED EDGE SHOUL BE NOTCHED AT CORNER

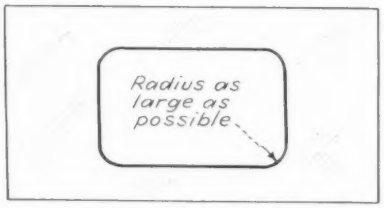
RADII

BEND FOR STAMPINGS

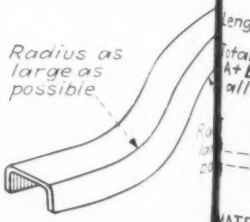


Radius four times metal thickness at bottom of drawn stamping saves drawing operations and prevents fractures

STAMPING DIES



RECTANGULAR HOLES

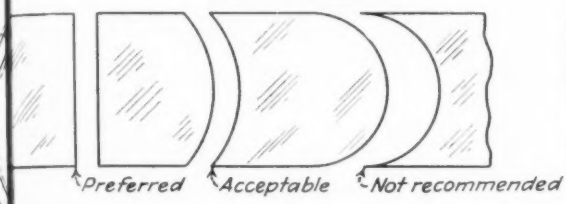


BENT FLANGED P

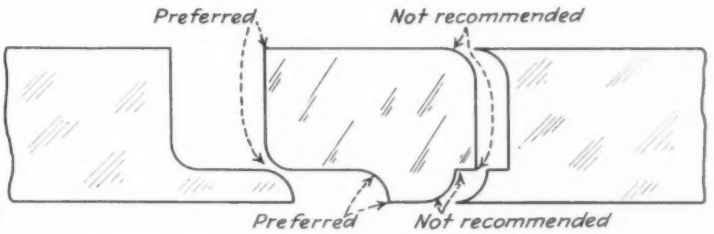
for Economy in Production

cut to shape—blanking, punching and trimming. The majority of stampings are made from flat sheet steel specified SAE 1008 for deep draws and SAE 1010 for simple forming operations.

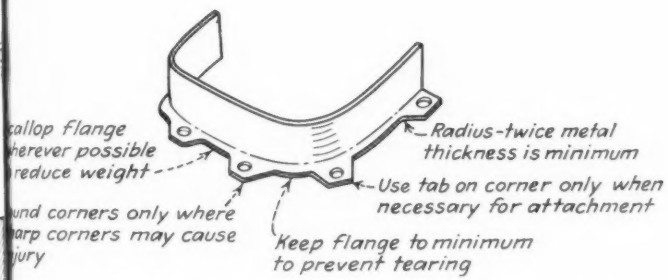
MISCELLANEOUS



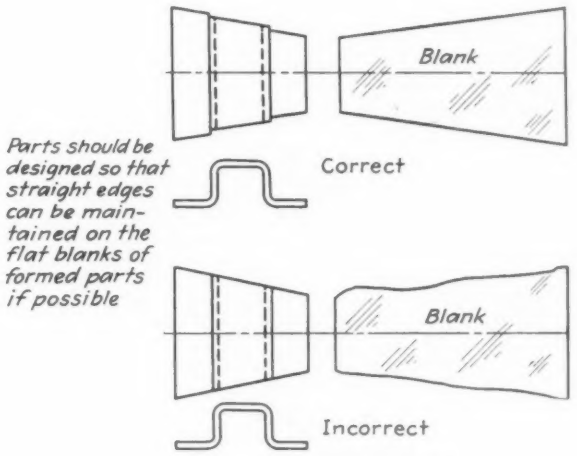
AVOID FEATHER EDGES WHEN SHEARING



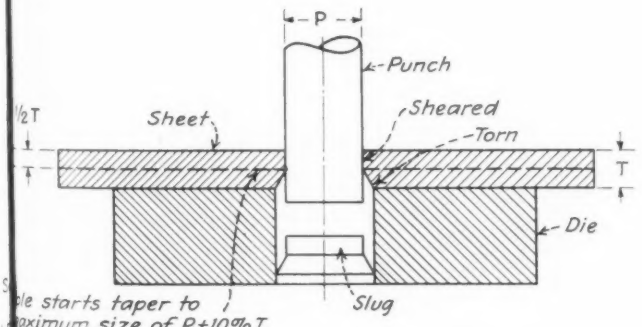
CORNERS ALONG EDGE OF STRIP STOCK SHOULD BE SHARP; INTERNAL CORNERS SHOULD BE ROUNDED, WHERE POSSIBLE


Radius-twice metal thickness is minimum
Use tab on corner only when necessary for attachment
Keep flange to minimum to prevent tearing

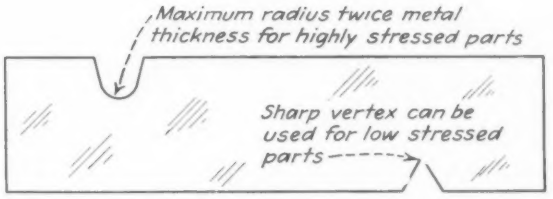
MAKE ALLOWANCE FOR DISTORTION AND VARIATION IN TAB SHAPE TO PERMIT PIERCING AND NOTCHING IN BLANK


Blank
Correct
Parts should be designed so that straight edges can be maintained on the flat blanks of formed parts if possible
Blank
Incorrect

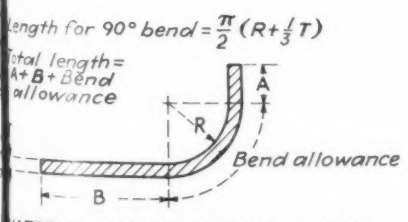
BLANK DESIGN



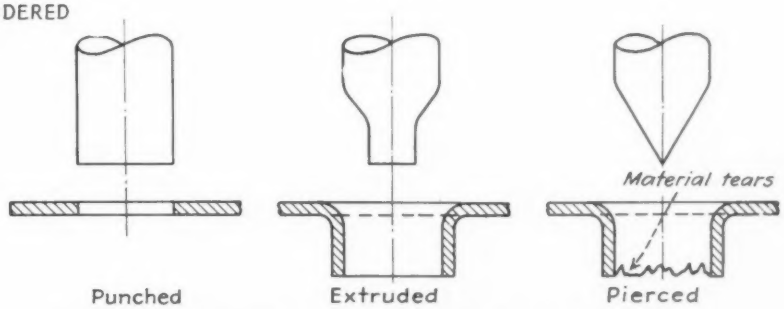
SHAPE OF PUNCHED HOLE MUST BE CONSIDERED WHEN IT IS TO BE A BEARING SURFACE



NOTCHES ARE OF TWO TYPES



MATERIAL NEEDED FOR FORMING BENDS



THREE METHODS FOR MAKING HOLES IN STAMPINGS

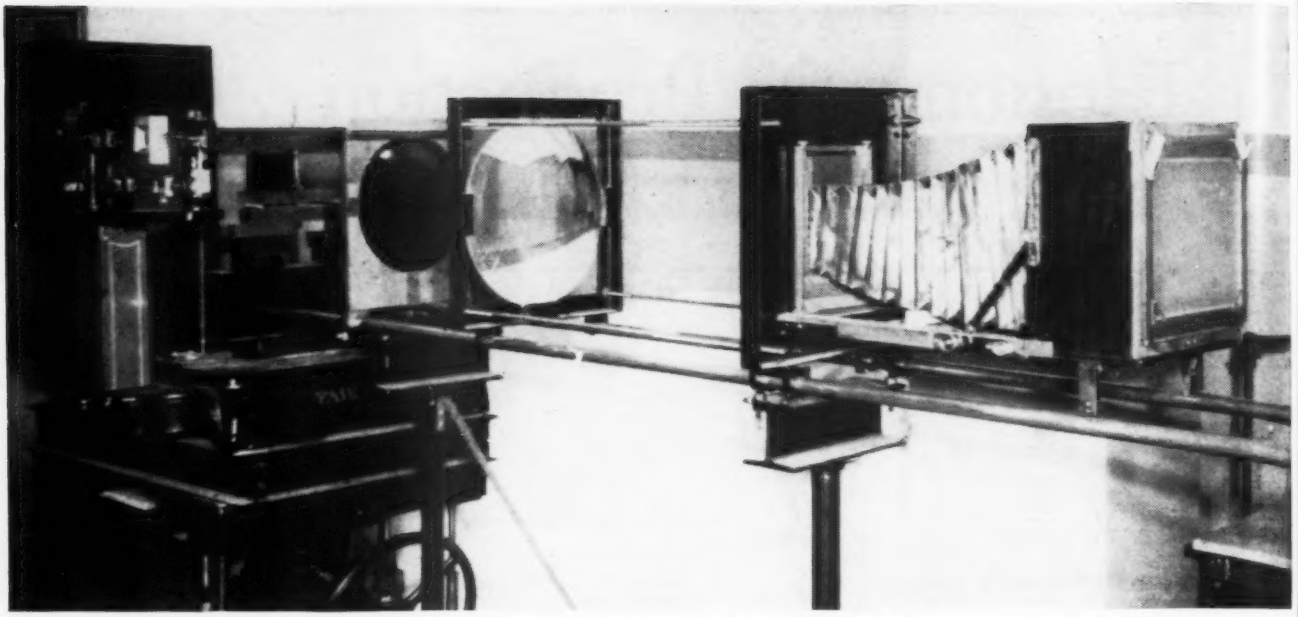


Fig. 1—Simple polariscope designed and built by the staff of the Structural Analysis Laboratory at M.I.T. The construction details are given in the article, so that any development engineer can duplicate this useful design aid.

A Simplified Polariscope for

RAY W. CLOUGH

Assistant in Structural Engineering
Massachusetts Institute of Technology

THE PHOTOELASTIC METHOD of stress analysis has never been widely employed in the industrial field in spite of its many advantages over other methods of evaluating stresses in machine components. One reason for the slowness in adopting this technique has been the relatively high cost of the photoelastic equipment available on the market. However, simplified equipment, adequate for the needs of most development engineering groups, can be constructed quite easily and inexpensively.

The photoelastic method has many advantages over other methods of stress analysis, which may be summarized as follows:

1. Compared with "trial and error" or empirical design methods:

a. Minimizes the need for high "factors of ignorance" which increase weight and cost of parts.

b. Reduces the cost of design changes since any design may be tested before the part is made.

2. Compared with mathematical analyses:

a. Not limited by the simplifying assumptions which must be made in all but the simplest mathematical studies.

b. More rapid than complicated and difficult mathematical solutions.

3. Compared with other experimental methods:

a. A more complete view of the stress pattern may be obtained, not just surface stresses at a limited number of points.

b. Stresses in otherwise inaccessible parts may be obtained (for example, in members that are fitted closely together).

c. The test can be completed quickly and inexpensively before the part is made.

The photoelastic method is also useful in checking analyses that have been made by other methods.

There are certain limitations to the use of photoelasticity which should be noted also:

1. Two dimensional models do not always represent the conditions of maximum stress in a three dimensional prototype.

2. Three dimensional analyses are difficult to make, and in general are beyond the scope of most small industrial firms.

3. Dynamic stresses, especially impact, are hard to obtain.

FUNDAMENTALS OF PHOTOELASTICITY

A brief explanation of the underlying principles will clarify the discussion on construction and use of the polariscope.

The photoelastic method of stress analysis is based upon two main facts:

1. The optical qualities of certain transparent materials are affected by stresses within the material.

2. The stress distribution produced by a given loading condition is the same in all homogeneous materials.

The first fact makes possible the evaluation by optical means of stresses within a model of some appropriate transparent material; the second fact permits the inference that these model stresses are the same as would exist in a similarly loaded metal prototype.

A material suitable for making photoelastic models has the property of becoming doubly refractive under stress; that is, light passing through this material is polarized so as to vibrate in two perpendicular planes, the planes of the principal stresses in the model. The difference between the velocity of the light rays in each of these planes is proportional to the difference between the principal stresses. Thus if the difference between the speed of light in each plane can be determined at any point in the model, a measure of the difference between the principal stresses at this point has been obtained. The polariscope simply provides a means of measuring the difference between the velocity of light rays vibrating in each plane.

CONSTRUCTION OF THE POLARISCOPE

A polariscope consists of the following components: A light source (both

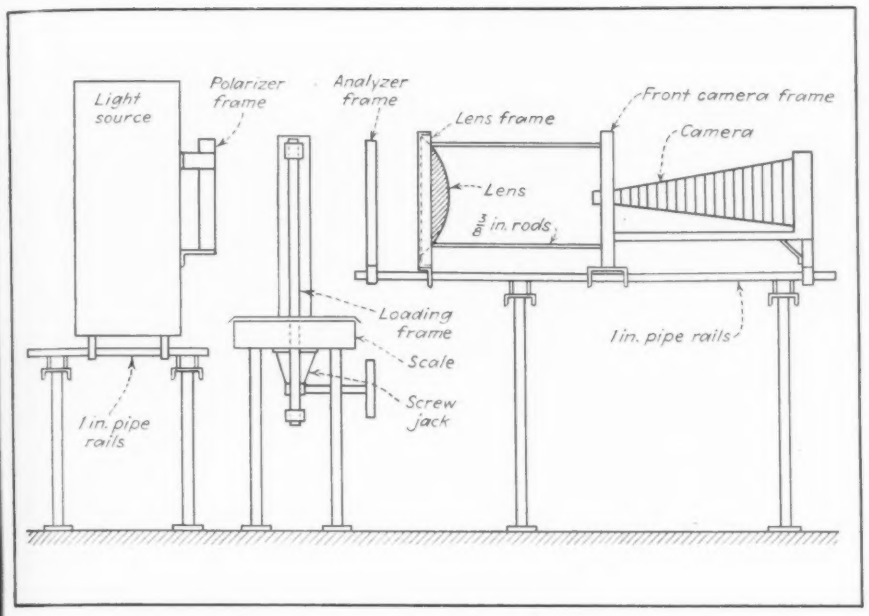


Fig. 2—General arrangement of the polariscope. Components are mounted on pipe rails for easy, rigid adjustment. An old portrait camera serves to photograph patterns.

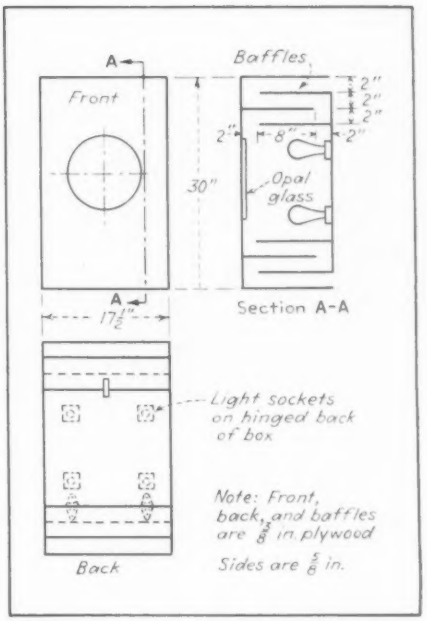


Fig. 3—Construction details of the incandescent light source for the polariscope.

for Industrial Use

monochromatic and white), a lens system for focusing the image upon the camera or screen, polarizing and analyzing disks mounted so that they may be rotated through 90 degrees, "quarter wave plates" for producing circularly polarized light, a camera with a ground glass screen upon which the image of the stressed model is projected, and a loading device for applying loads to the model.

The simplified polariscope, designed and built by the staff of the Structural Analysis Laboratory at M.I.T., is shown in Fig. 1. It was found to be a satisfactory instrument, both with respect to its performance, which was efficient and accurate, and its cost, which was surprisingly low for its size.

A diagrammatic sketch indicating the general arrangement of the polariscope is shown in Fig. 2. Components of the polariscope are designed to ride on the pipe rails of the rigid base or "optical bench." This arrangement allows for any necessary adjustment in focus or in position of the model.

The light source of the polariscope, Fig. 3, is inclosed in a plywood box, which is ventilated by a system of lightproof baffles. Four ordinary light sockets are mounted on the back of the box to hold the 100 watt bulbs which constitute the white light source. A mercury vapor lamp mounted in the center of the base of the box provides the monochromatic light. The interior of the box is painted white to increase its light reflecting qualities and the baffles are painted flat black to reduce light leakage. The inner surface of the hinged back of the box is covered with a thin sheet of duralumin which acts as a reflector; a piece of asbestos placed between the metal and the plywood serves as insulation.

A piece of opal glass which diffuses the light is fastened inside the box over the 10 in. circular aperture at the front; metal clips are provided at either side of the opening on the outer face of the box to hold a 12 in. square green filter in place. This filter is used with the mercury vapor lamp to provide the monochromatic light source. It is composed of a filter film (Wratten Filter No. 62) sandwiched between two pieces of glass, which in turn are mounted in a light wooden frame.

The polarizer and analyzer used in this polariscope are identical disks 10 in. in diameter. They each consist of a sheet of Polaroid and a quarter wave plate combined in a single unit. When they are placed in the polariscope with the Polaroid side toward the model, they produce plane polarized light. With the quarter wave plate toward the model circularly polarized light is produced. These complete units may be purchased ready for use.

The frame in which the polarizer is mounted is attached to the front face of the light source box. This frame, Fig. 4, is formed of $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$ in. angles. Small U-shaped brackets for supporting the polarizer disk are fastened to the inner faces of the angles. They hold it securely against

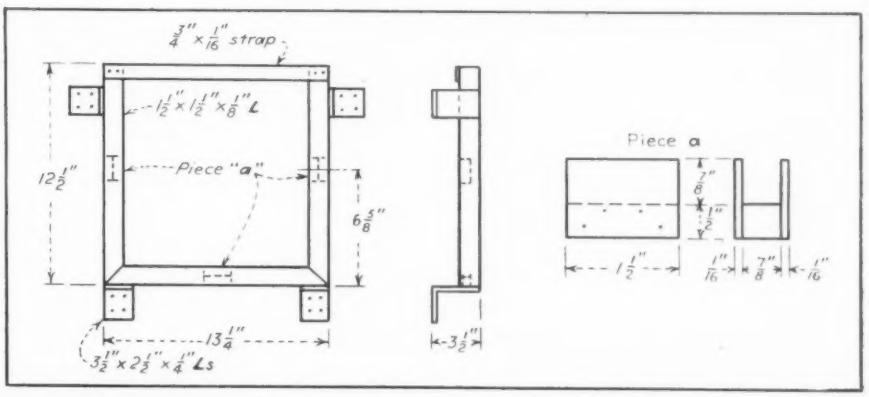


Fig. 4—Construction of polarizer frame, which is mounted over light source.

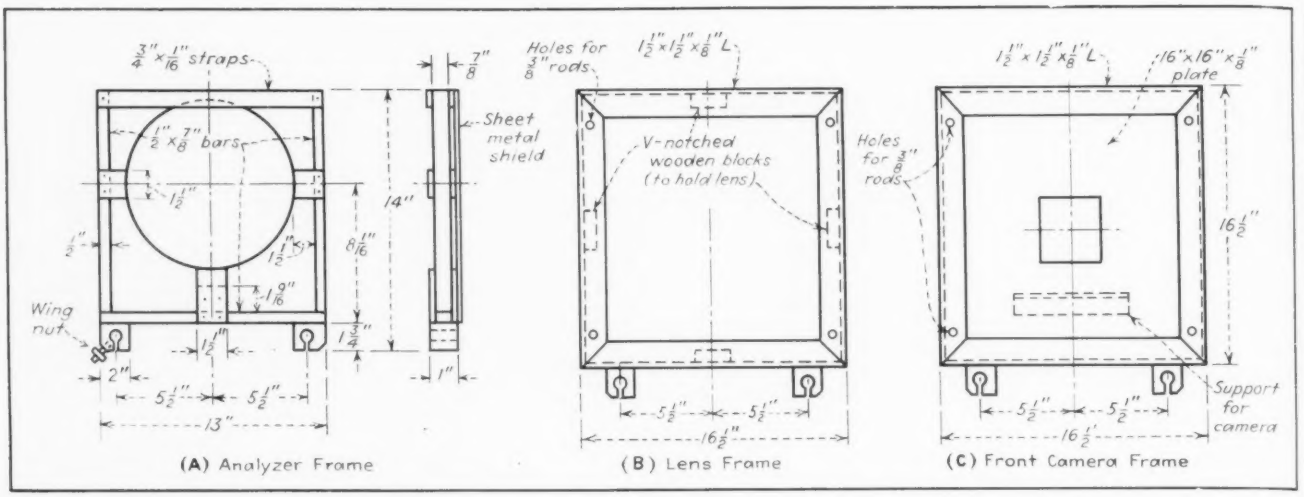


Fig. 5—(A) Construction of the analyzer frame. (B) Construction of the lens frame. (C) Front frame for mounting the camera.

any translatory motion but allow it to be rotated freely.

The analyzer is mounted in a similar frame on the opposite side of the model and loading frame from the polarizer. The analyzer frame, Fig. 5, also has U-shaped brackets into which the disk fits. In this frame, however, one of the brackets has a pointer attached which indicates the orientation of the disk by a scale marked in degrees along its edge. Also a metal shield with a 10 in. dia hole is attached to the face of the frame so that no light can pass around the edge of the analyzer disk.

The lens system consists of a single uncorrected condensing lens, 14 in. in diameter. It is connected rigidly to the camera in such a way that the focal points of the lens and camera coincide. This single lens system was adopted because lenses of this size, even uncorrected, are rather expensive. The cost of an optically perfect lens of this diameter would have been prohibitive, but it was found that if only the center portion, approximately 8 in. diameter, of the uncorrected lens were used, the aberration errors were small.

The optical system of this single lens polariscope operates as follows: The opal glass acts as the true light source, emitting light in all directions. This light passes through the polarizer, model, analyzer, and lens. On passing through the lens, the rays of light converge toward the camera. However, only those rays that were parallel to the axis of the polariscope will converge at the focal point of the camera and be projected upon the screen. All other rays will be out of focus and thus will not be seen. This system has the disadvantage that a large percentage of the light emitted by the light source is wasted, but the only effect of this loss is to require longer exposures in taking photographs.

The lens is mounted in a frame, Fig. 5, formed from $1\frac{1}{2}$ x $1\frac{1}{2}$ x $\frac{1}{8}$ in. angles. Wooden V-notched brackets that support the lens are attached to the inner faces of the angles. The lens frame is connected rigidly to the frame that supports the front end of the camera, Fig. 5, with four $\frac{3}{8}$ in. bolts.

The camera used in this polariscope is an old portrait camera, obtained from a dealer in used photographic equipment. It is an 8 x 10 in. plate type of camera with a ground glass screen at the back to assist in focusing. This type of camera is ideal for photoelastic work, since it may be used either for taking photographs of the loaded model or for inspecting the image directly.

The model loading frame may be used for either tension or compression tests. It has a capacity of 1,000 lb, which is sufficient for almost any photoelastic work. The base of the frame (see Fig. 6) supports a 1,000 lb capacity platform scale. A screw jack is mounted in an inverted position under the scale, and to its head are attached a pair of loading screws which pass up through clearance holes in the scale platform. These screws are connected to a loading beam above the platform. For compression tests, the model is placed between the scale and the loading beam. As the screw jack is turned, the bar is caused to bear down upon the model, which in turn bears on the scale. The net load on the model is obtained by subtracting a tare reading from the gross weight

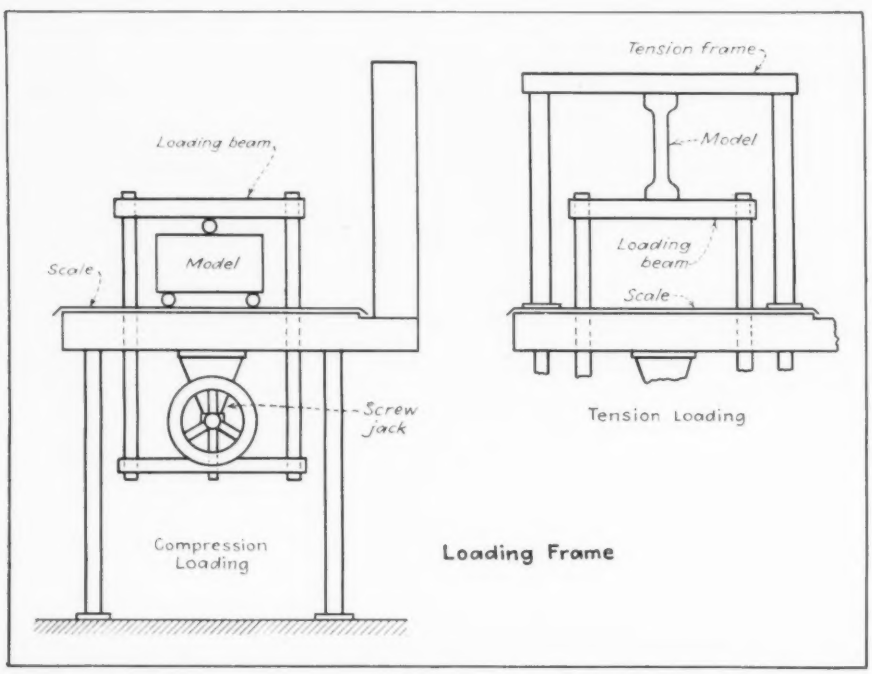


Fig. 6—Diagram of arrangements for loading the model in tension and compression.

recorded during the test. Fig. 6 shows the arrangement of the loading frame as used in compression tests.

For tension tests another frame must be added to the loading machine. This frame rests upon the scale and extends up over the loading beam. The model is connected between the loading beam and the tension frame. Thus as the screw jack is turned and the loading beam descends, a tensile load is applied to the model. This causes the tension frame to bear down on the scale, so the load may again be measured. A compression and a tensile specimen, Fig. 7, are shown in the loading frame.

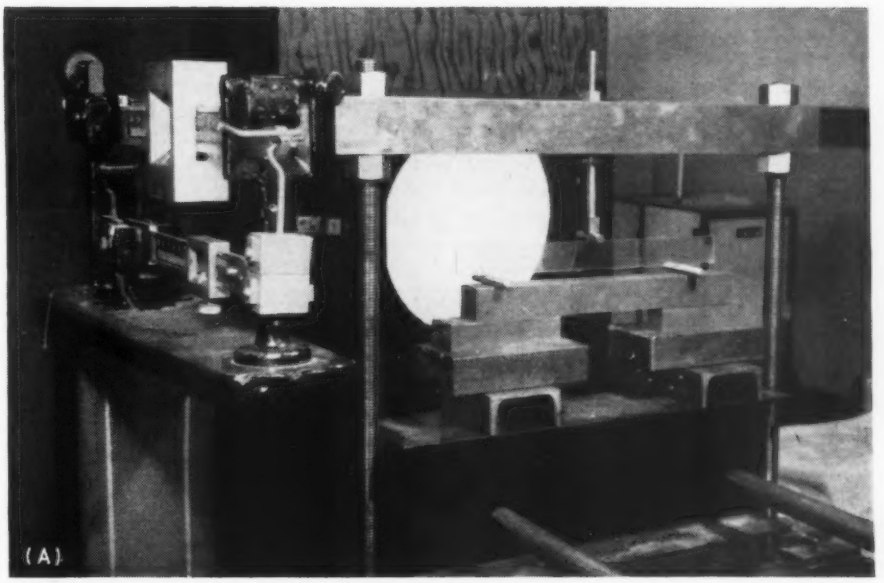
The individual parts of the polariscope are mounted on 1 in. pipe rails as shown in Fig. 2. In operation the parts are moved as close together as possible; the polarizer and analyzer frames are placed as near the model as is practicable and the lens is moved up flush against the analyzer. The polarizer and analyzer disks are placed in their respective frames and rotated until their axes are at 90 deg to each other. This position is determined as the one at which a minimum amount of light is transmitted through the combined polarizer and analyzer disks.

Preparation of Models

Many materials, including glass and celluloid, have the property of polarizing light when stressed, and could theoretically be used for photoelastic models. However all of these materials have some undesirable properties; for example, glass is brittle and hard to work with, and celluloid creeps under load. Cast phenolic resins can be used for qualitative work, but the material that has been found most suitable for quantitative photoelastic work is a certain phthalic anhydride (BT-61-893). This substance has most of the properties of a good photoelastic material and only a few undesirable qualities, most serious of which is an aging effect that will be discussed later.

This plastic may be purchased in sheets that are polished and annealed, although some laboratories prefer to obtain it in the rough form and polish and anneal their own specimens. The model of the part to be studied is cut roughly to size from this polished pthalic anhydride on a band or jig saw. Then it is machined accurately to its final dimensions in a vertical milling machine. In machining, it may be handled like a soft brass. When the machining has been completed the model must be tested as soon as possible. Speed is essential because of the aging effect to which reference was made earlier. All edges of the plastic begin to age as soon as they are exposed to the air. Within a few hours the optical properties of the edges will have changed to a considerable degree. This serious effect should be kept to a minimum since edge stresses in the model usually are of the greatest interest.

State of stress at any point in a two dimensional model may be completely determined if three quantities concerning the stresses at that point are known. In photoelastic analyses, the three quantities used are: (1) Difference between the principal stresses, (2) Direction of the principal stresses, (3) Sum of the principal stresses. All three may be obtained from the photoelastic analysis, but usually it is simpler



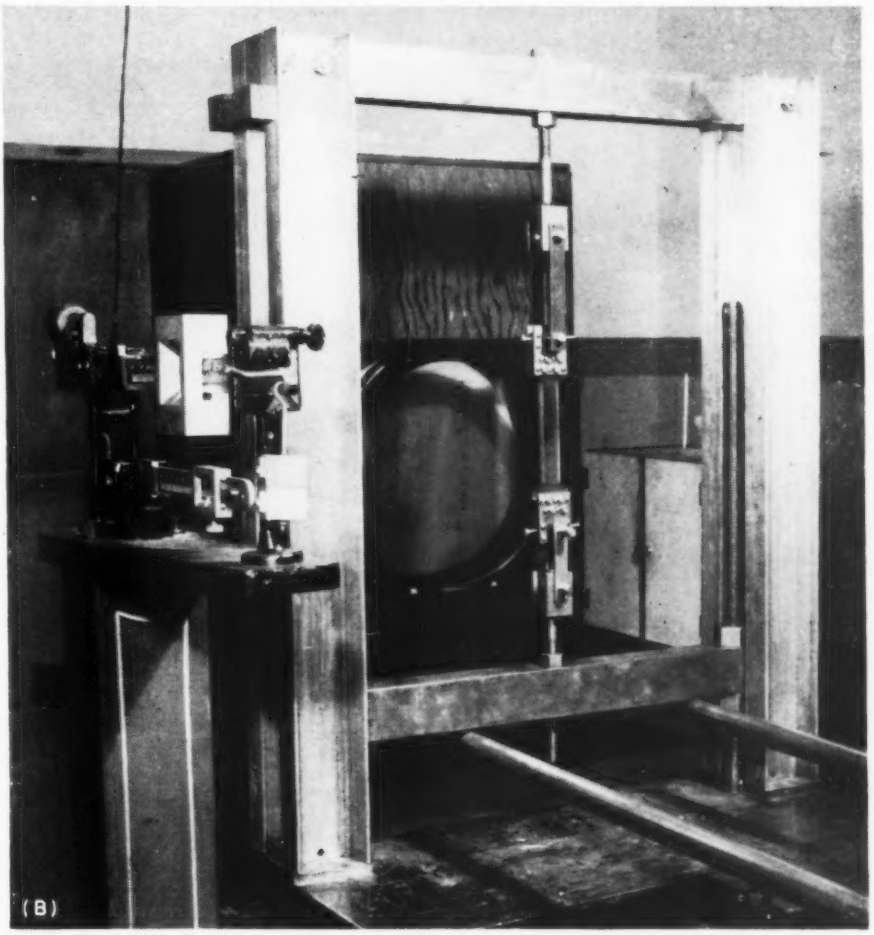


Fig. 7—(A) Loading a plastic model in compression. (B) Loading a model in tension.

to obtain only the first two with the polariscope, and to determine the sum of the principal stresses by measuring lateral strains in the loaded model with an extensometer of some sort.

The difference between the principal stresses is determined in a photoelastic analysis from a pattern of lines that appear on the stressed model. These isochromatic lines connect points on the model at which the same difference between the principal stresses exists. When a monochromatic light source is used in the polariscope, they appear as a series of dark and light lines; when white light is used, they are lines of constant color, each band of lines shading in color through the entire spectrum.

The orientation of the principal stresses is obtained from another set of lines on the model called isoclinic lines. These are dark lines, when either the monochromatic or white light source is used, that connect all points on the model at which the principal stress directions are parallel to the axis of the polarizer or analyzer disk. If the polarizer and analyzer are rotated, the position of these lines will change. When circularly polarized light is passed through the model the isoclinic lines disappear; in effect, the polarization axis of the light is rotating rapidly and the isoclinic lines move so fast that they cannot be seen.

In many stress analyses, determination of the tensile and compressive stresses at the edges of the model will be sufficient, since the maximum stresses usually occur at these points. These edge stresses may be determined readily from the isochromatic pattern alone. They may be obtained from this single quantity because at any boundary the normal stress, which is one of the principal stresses, must obviously be zero. Hence, the difference between the principal stresses is equal in magnitude to the tangential edge stress.

If the stress distribution within the model is to be studied, all three of the quantities that are measures of the stress, i.e. the isochromatic and isoclinic patterns and the lateral strains, must be obtained. The technique of obtaining these quantities will be discussed in a subsequent article, at which time interpretation of test results will also be considered.

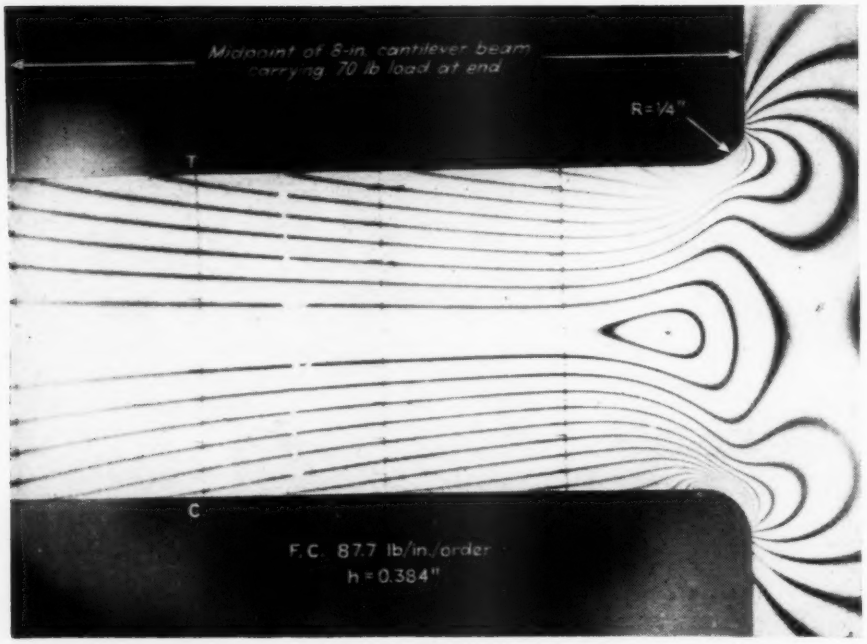


Fig. 8—Isochromatic pattern in a cantilever beam. The picture shows only half, or 4 in., of the beam length. The 8 in. dimension only locates the loading.

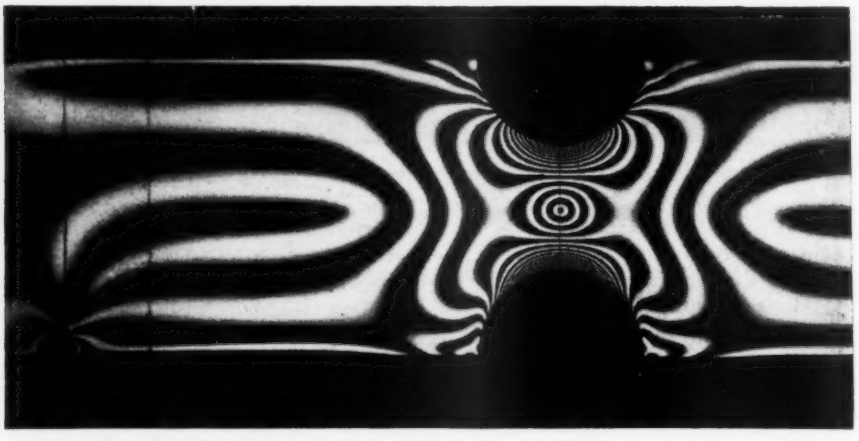


Fig. 9—Notched beam subjected to bending stresses. The isochromatic pattern indicates stress concentrations of 8.5 times as high as stresses away from the notch.

Examples of Isochromatic Patterns

The isochromatic patterns obtained with two typical loaded specimens are shown in Figs. 8 and 9. The cantilever beam in Fig. 8 demonstrates the pattern associated with simple bending stresses. In this model, each isochromatic line represents an increment in the difference between the principal stresses of 87.7 lb per in. on the basis of a model of unit thickness, or since the model is 0.384 in. thick, 228 psi per line. Along the straight portions of the beam, the uniformly increasing edge stresses are indicated by the equidistant spacing of the isochromatics along the edges. In the vicinity of the fillets the close spacing of the lines indicates sharply increasing stresses, and thus demonstrates the existence of the stress concentrations which are to be expected at the root of a cantilever. By counting the isochromatic lines it may be seen that the maximum stress in the fillet is about 50 percent higher than it would be were there no stress concentration.

The isochromatic pattern shown in Fig. 9 is that produced by a notched beam subjected to pure bending stresses. It clearly shows the effect of the notches in producing stress concentrations. A beam having a constant width equal to the width of the narrowest part of this beam would have edge stresses 5.7 times as high as a beam uniformly as wide as the widest part subject to the same bending moment. However, the edge stresses in the notch of this beam, as indicated by a count of the isochromatic lines, are 8.5 times as high as the edge stresses away from the notch. Thus the stress concentration effect has produced notch stresses in the ratio of 8.5:5.7 or about 150 percent of the value which would otherwise be expected.

EDITOR'S NOTE: A second article by Mr. Clough will follow soon to explain the determination of stress values, using the polariscope described here.

PLASTICS . . .

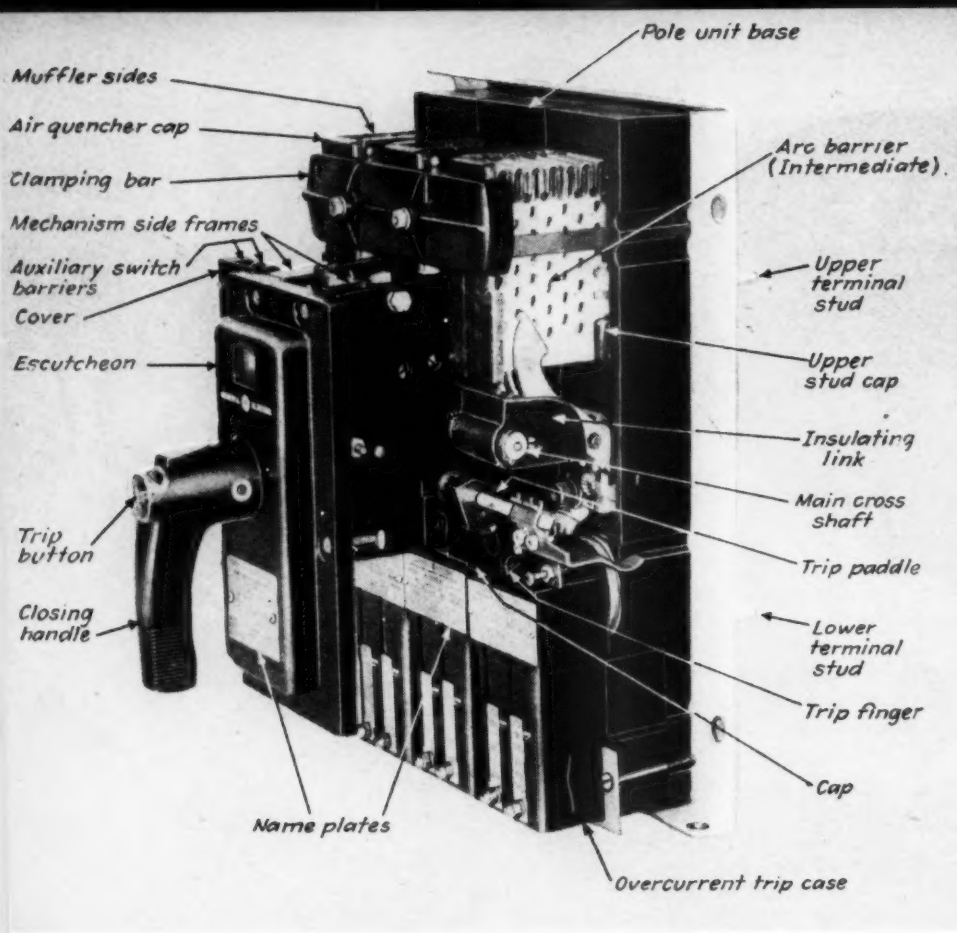
Intelligent use of plastics in product design is following the same course of development that marked acceptance of such established materials as stainless steel and the light metals.

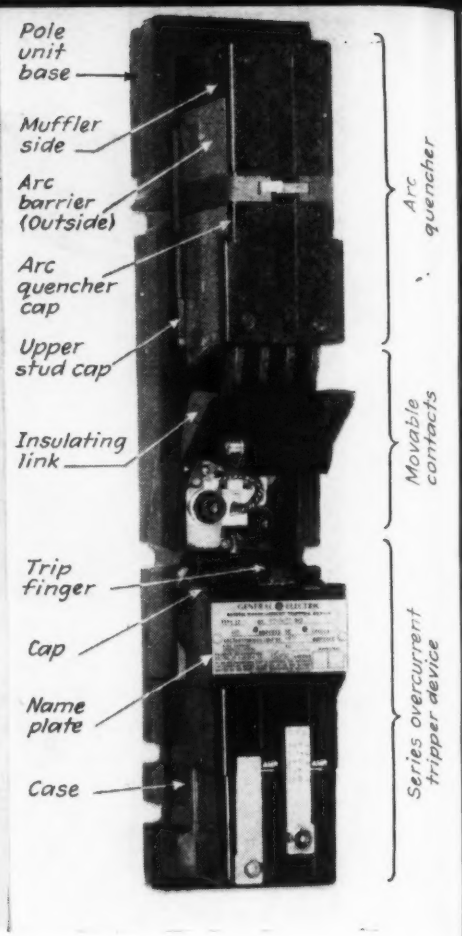
As far as the engineer is concerned, maturity has been achieved.

ARE ENGINEERING MATERIALS . . .

Plastics are attractive engineering materials: They offer advantages in weight savings, lower costs, moisture and chemical resistance, toughness and abrasion resistance, and many other specific functional qualities that are the everyday concern of the design engineer.

AS SHOWN BY THEIR FUNCTIONAL USE IN . . ⇨





COMPLETE BREAKER, with one outside arc barrier removed showing contacts and center arc barrier. Front escutcheon and side frames are large cotton filled molded phenolic parts. Normally, frames would be punched and welded of steel or die cast.

POLE UNIT sub-assembly (right). The interrupting unit or "arc quencher" uses three different molded plastics. In the center are the movable contact fingers with their molded plastics operating link. At bottom is series overcurrent tripping device.

. . . Heavy Duty Electrical

GE redesign of circuit breaker saves space and weight, through

A THIRTY PERCENT reduction in size, improved performance and appearance, and increased ease of production has been accomplished in the redesign of General Electric's new AK-1 air circuit breaker. Even more significant, the complete redesign is attributed directly to increased use of plastics.

Plastics were responsible for obtaining the following desirable features:

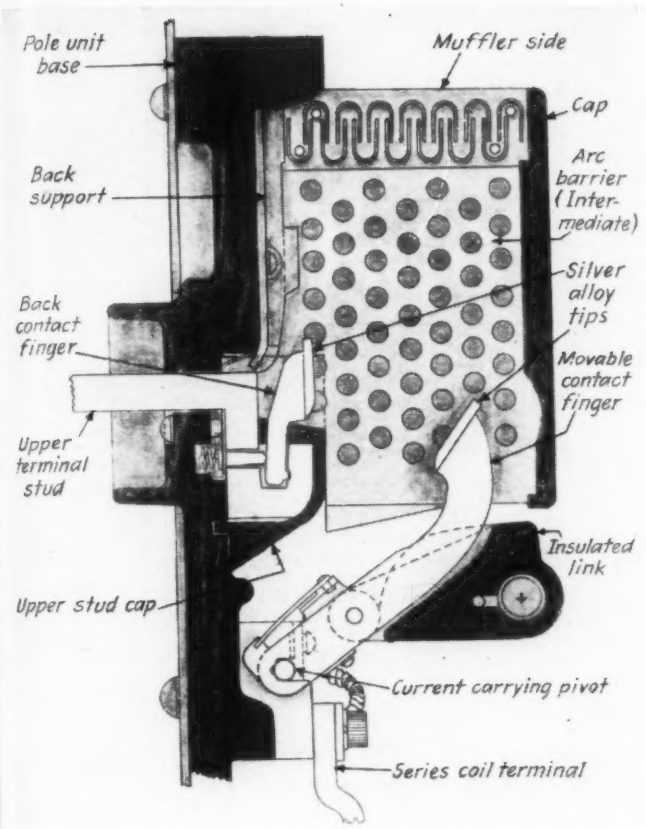
1. Complete shielding of live parts.
2. Structural members which are inherently insulators. Thus, plastics replacing steel meant a two-fold saving in weight and size.
3. A thirty percent reduction in size—four circuit breakers now occupy the space of three.
4. Elimination of costly machining operations, through the use of molded plastic parts.
5. High resistance to arc erosion.
6. Improved, "streamlined" appearance.

The molded parts have been designed to form an inclosure for many of the components, thus shielding parts which are electrically energized. A "dead front" design is obtained without the use of additional inclosing barriers. Calibration adjustments are insulated so that an operator can set them while the equipment is energized.

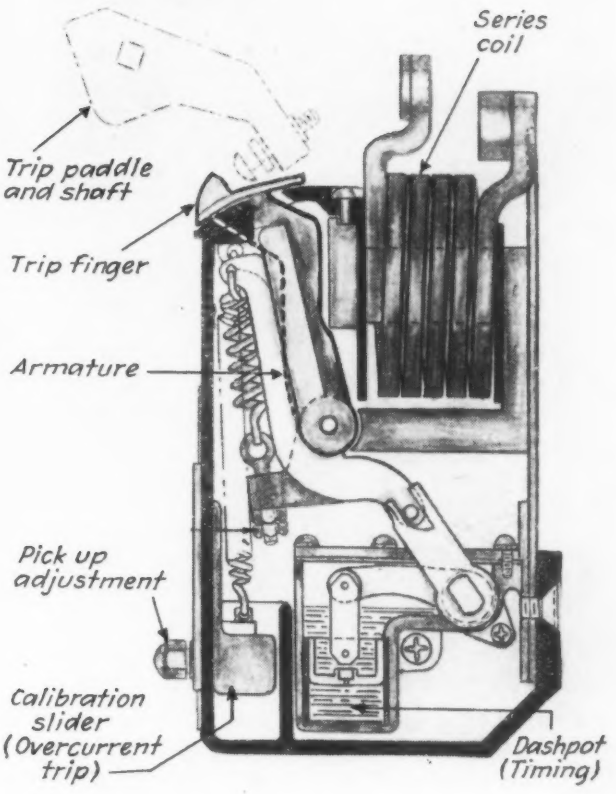
In order to reduce the size of the circuit breaker, it was found necessary to make some of the structural frames and

Plastic Materials in Redesigned Circuit Breaker

PART	MATERIAL
Pole unit base	Cotton filled phenolic
Right and left muffler sides	Asbestos filled phenolic
Three center barriers	Cold molded phospho-asbestos
Right and left side barriers	Cold molded phospho-asbestos
Front cap	Asbestos filled phenolic
Stud cap	Asbestos filled phenolic
Insulating link	Asbestos filled phenolic
Overcurrent trip arm	Asbestos filled phenolic
Overcurrent trip cap	Cotton filled phenolic
Overcurrent trip case	Cotton filled phenolic
Two overcurrent trip slides	Cotton filled phenolic



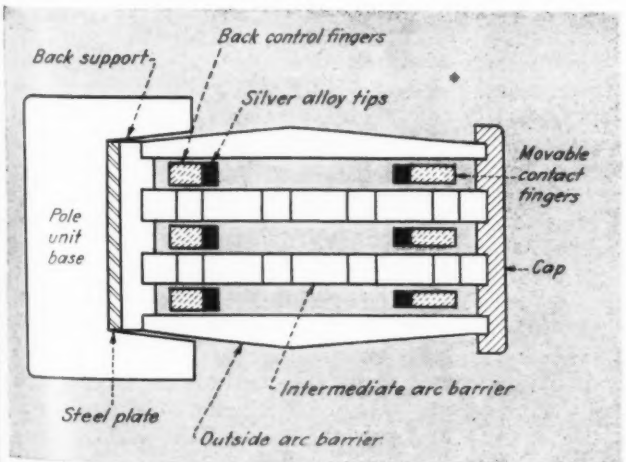
COMPLETE interrupting unit, consisting of arc quencher and contacts, which operate in narrow slots created by molded phospho-asbestos arc barriers. This material withstands the heat and erosion of 25,000 ampere interruptions.



CASE for the overcurrent tripping device, shown in heavy black outline, forms a protective cover for the accurate timing elements. This shows optimum design in high strength cotton flock filled phenolics, in deep thin walled sections with little draft.

Equipment

the extensive use of plastics



HORIZONTAL cross-section through contact tips and arc quencher, showing the multiple slots and contact finger arrangement. When closed, the movable contact finger pivots about the bottom end to engage the back contact finger.

mechanism linkage of an insulating material. To design around metal frames and linkages with added insulation required considerably more space than molded plastics parts. Modern molded phenolics, both cotton and asbestos filled, provided the high mechanical strength and shock resistance to make such a design possible.

The design of present day circuit breakers, with their many accessories, frequently require parts of complicated shape. The cost of machining such parts would be prohibitive. Molding provides an ideal way of reproducing these shapes in large quantities, with good accuracy.

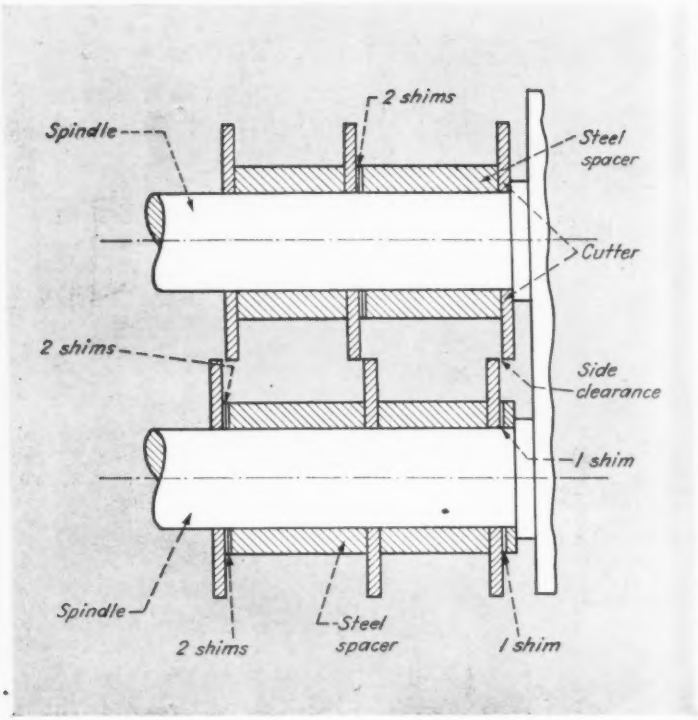
In addition to making intelligent use of established plastics, as shown in the accompanying illustrations and captions, General Electric engineers developed a special material for use as interrupter barriers. This "phospho-asbestos" material, made of phosphoric acid and asbestos, is cold molded into barriers which easily withstand the heat and erosion from 15,000 and 25,000 ampere arcs. No other material has been found to give equivalent performance.

This new breaker, Type AK-1-15 and AK-1-25, has been designed in two frame sizes, 225 and 600 amp. The interrupting ratings are 15,000 and 25,000 amp at either 250 volts dc or 600 volts ac. Continuous current or series trip coil ratings from 15 to 600 amp have been provided. Two, three or four pole manually or electrically operated units are available for dead front stationary, drawout switchboard or individually enclosed mounting.

EDITOR'S NOTE: This section is based on information and illustrations furnished by L. H. Sperow, Air Circuit Breaker, Engineering Section, Switchgear Divisions, General Electric Company, Philadelphia, Pa.

Yoder Manufacturing Company

PRODUCTION of this steel slitting machine is speeded, costs lowered through the use of easily identified colored plastic spacing shims. Since thickness is keyed to color, the proper spacer can be immediately chosen.



CUTTER ASSEMBLY setup of Yoder slitter shows function of plastic shims, and their position relative to cutters and steel spacers. As shown, an allowance must be made for side clearance of the cutters—10 percent of the thickness of stock. Plastic is dimensionally stable.

. . . Heavy Production Machines

Color-Thickness Identification of Plastic Spacers Speeds Production

ONE of the most unusual applications of a thermoplastic material is its use in heavy machines, where dimensional stability is important. Showing unusual adaptability as thin and accurate spacers, cellulose acetate shims are produced by Industrial Products Suppliers, New York, by a special die-cutting process.

The novel feature of these plastics shims is the fact that their thickness is identified by their color. As shown in the table, these shims are supplied in a range of thicknesses from 0.001 inch up to 0.060 in. They are available in any diameter up to 20 in. The only color that is "repeated" is black; however this is no handicap, since there are few applications that would utilize the full range of thicknesses.

When these shims are used as spacers, production costs are cut through elimination of workmen's time loss. Makeshift spacers need no longer be produced, cost of accurately-ground steel spacers is eliminated, and the proper spacer can be immediately chosen.

The Yoder Manufacturing Company, Cleveland, Ohio, which produces a line of gang slitters (one model of which is shown on the cover of this issue), supplies prepared packages of these spacers with each machine, in a range of thicknesses from 0.003 in. to 0.060 in. The exact location and function of the plastic shims in the cutter assembly are shown in the accompanying illustrations. Machine manufacturers report that the cellulose acetate shims are far superior to the oil-paper and leather spacers which were formerly used. Although cellulose acetate is a thermoplastic, it was found to be quite incompressible in these small thicknesses. This is not true of paper. The cellulose acetate sheets are produced in thicknesses with extremely close tolerances—this could not be obtained with either leather or paper. The shims retain dimensional accuracy up to 200 F. For applications above this temperature, heat-resistant plastics, such as Teflon, are being tested.

These shims can also be used as shim gaskets. Their water resistance is excellent, and they can withstand continuous oil immersion up to 180 F. and intermittent oil immersion up to 200 F. Spindle oil was used to determine these values.

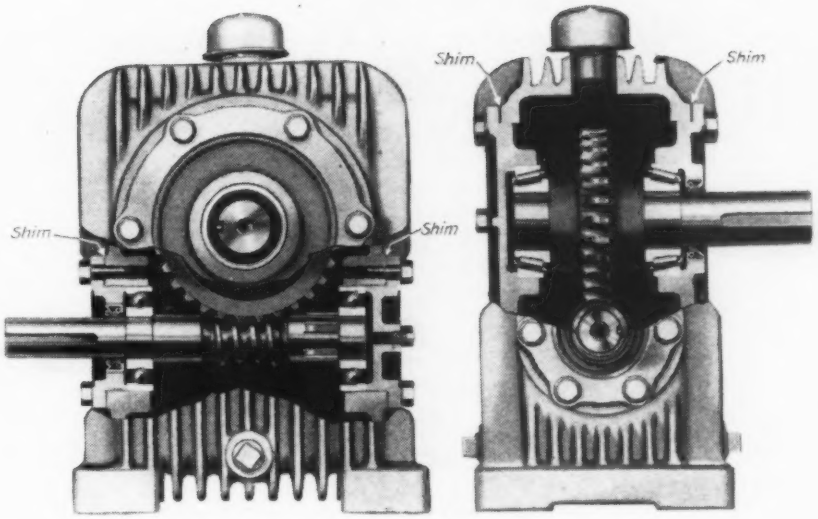
To test compression, 0.020 in. and 0.005 in. shims were placed between smooth steel plates which were bolted together with three bolts. The overall width of the plates were carefully measured before and immediately after tightening the nuts, and again at the end of the test, seven days later. Although the average torque to remove each nut was 215.8 in.-lb, the loss in overall width of the fixture was only 0.0002 in. The shims were in good condition after the fixture was taken apart.

A similar use of these shims is made by the Michigan Tool Company, Detroit, in their "Cone-Drive" gear re-

COLOR OF CELLULOSE ACETATE SHIMS FOR VARIOUS THICKNESSES

THICKNESS, IN.	COLOR
0.001	amber
0.0015	purple
0.002	red
0.003	green
0.005	blue
0.0075	transparent
0.010	brown
0.0125	black
0.015	pink
0.020	yellow
0.025	white
0.030	coral
0.060	black

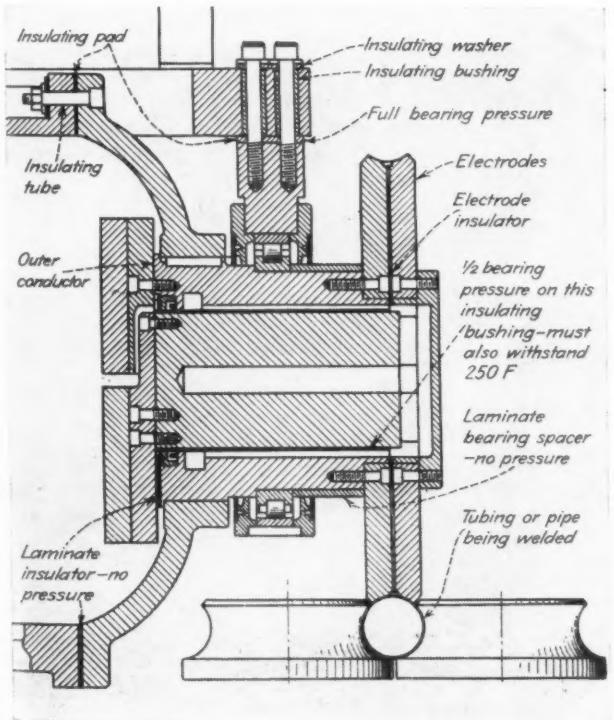
ducers. To accurately maintain the end adjustment of the pinion shaft (analogous to the transverse adjustment in other types of gearing) the shims are placed between the speed reducer housing and the end plates on the shafts that control the in-and-out location of the supporting bearing.



Michigan Tool Company

CONE-DRIVE GEARING is assembled with the aid of plastic spacing shims. The housing is checked by gage just prior to assembly and is marked for proper color (thickness) of shim to be used in each location. The shims are put in place, registering with the mounting plate stud holes on the housing.

For Electrical Insulation and Bearing Strength



An interesting example of how one plastic material is used to serve two different functions on a single machine is seen in the tube mill welders manufactured by the Yoder Company. A fine weave fabric-phenolic laminate tubing, (Micarta No. 97) molded at relatively low pressure, serves both as electrical insulation and to take bearing loads in this machine. Distribution of the bearing pressure is indicated in the accompanying diagram. It should be noted that the bushing which takes one half of the full electrode pressure (5,480 psi) must also withstand 250 F. The welder operates on both 60 and 180 cycle alternating current.

Here is how Westinghouse rates this material, compared with other laminates: Lowest moisture absorption, best dimensional stability, resistant to acid and alkali, good compressive strength. Other applications of this laminate include pneumatic pistons, wet chlorine gas tubing systems, ball retainers, and outdoor fan covering.

The laminated phenolic tubing has properties more than ample for this application, including compressive strength of 23,000 psi, impact strength of 0.283 ft-lb, dielectric strength, dry, of 200 ($\frac{1}{16}$ in. wall), and power factor 106 cycles) of 3.8 percent.

. . . Home Appliances

Plastics are Combined for Appearance, Weight Savings, Electrical, Heat and Moisture Resistant Qualities

Sleeping Comfort . . .

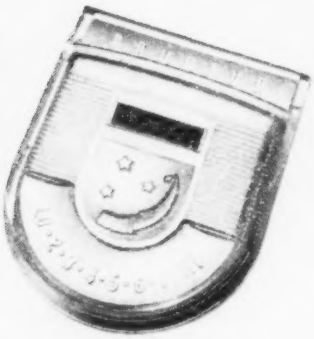
ALL OF THE PROBLEMS of a household appliance rolled into one—surface beauty, dimensional stability, electrical and heat resistance, resistance to aging, color stability—are combined in the heat control unit of the new electric blanket manufactured by the Proctor Electric Company, Philadelphia, Pa.

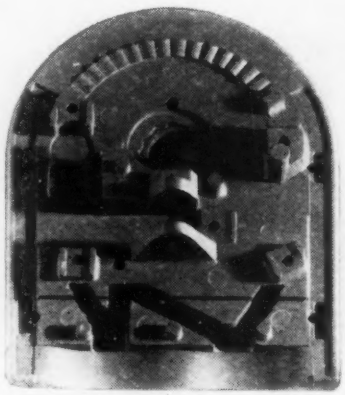
As shown in the accompanying illustrations, this unit consists essentially of two parts: A cover piece, molded of heat resistant acrylic and the base—to which all of the wiring and metal inserts are attached—molded of a woodflour-filled phenolic.

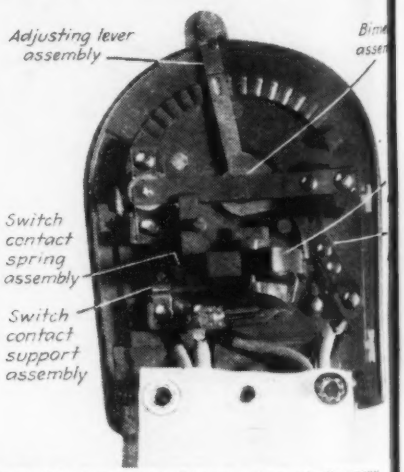
The acrylic cover was designed to present an appearance which would attract attention. A transparent material was chosen to provide the desired three dimensional effect; this effect was enhanced by spraying a metallic paint on the underside of the transparent cover. Thus, the numerals on the dial stand out in bold relief, and there is no problem of rubbing off, as with numerals that are painted on the top surface. In order to hide the screws which would ordinarily be detrimental to the appearance of the transparent cover a novel method of securing was devised. This method was made possible only through the dimensional stability of the two materials, and the close tolerances to which they could be molded.

A heat resistant formulation (Plexiglas V) was used so that the part would not distort if placed near a radiator. This formulation also has exceptional resistance to aging. The impact strength of this material is high, thus insuring against breakage caused by dropping. When dropped, there is none of the distortion of metals or the breakage of glass. Unlimited design possibilities are achieved because of the versatility of the molding process.

Although the base is molded of a conventional woodflour-filled phenolic, a special problem arose in regard to color. In order to blend with the predetermined color scheme, a special shade of gray was needed. For this application, Monsanto developed a special gray pigment. Soft flow material characteristics were required in this compound in order that it would fill all the small holes and crevices in the mold. These holes and crevices formed the many small projections on which the internal parts are mounted.



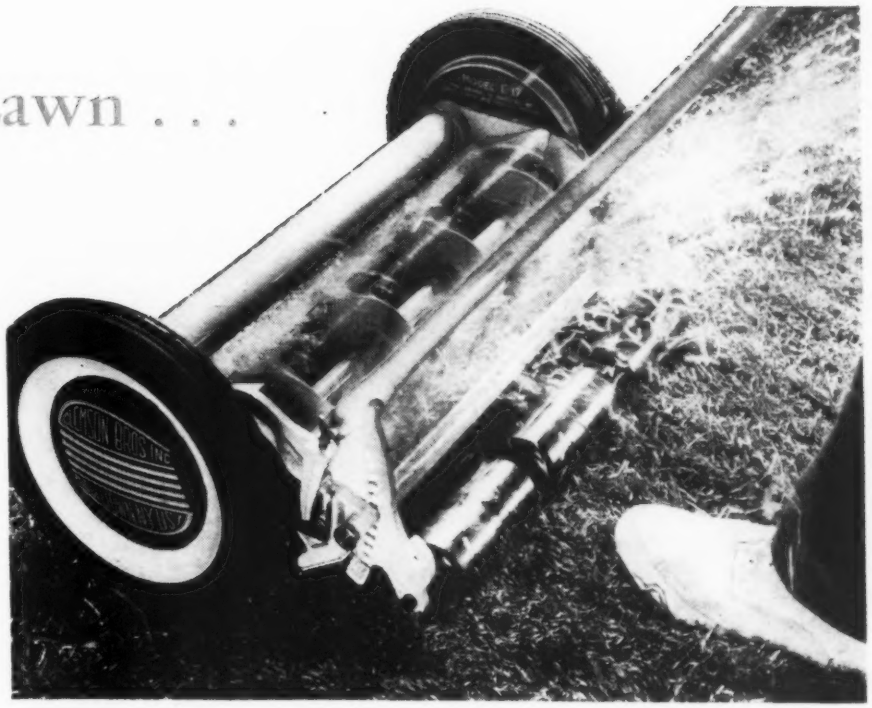




Rohm & Haas Company and Proctor Electric Company

COMPLICATED assembly of heat control unit is made up of intricate plastic moldings, combined with metal stampings. At left, is heat resistant acrylic cover, which achieves a three dimensional effect with a metallic paint sprayed on the underside. Acrylic molding powder, Plexiglas V, was developed for heat resistance, moldability and optical properties. Center illustration shows molded phenolic base, main structure of the unit. At right, metallic parts and wiring are attached to base.

For the Lawn . . .



A FOUR-POUND weight reduction, plus an appreciable price reduction on the new Clemson model E-17 lawn mower, is attributed to use of plastics in the redesign.

Used primarily for its toughness and moisture-resistance, plastic parts on the Clemson mower are made of cellulose acetate butyrate. These include: Three-piece rollers, injection molded around a metal bushing, dust covers, reel bearing seals, and handle parts cemented to a die-cast zinc core.

Formerly made of metal and wood, these parts are now molded of plastic because of ease of fabrication and beter performance. Under the latter heading, it should be noted that the mowers are subject to the following conditions.

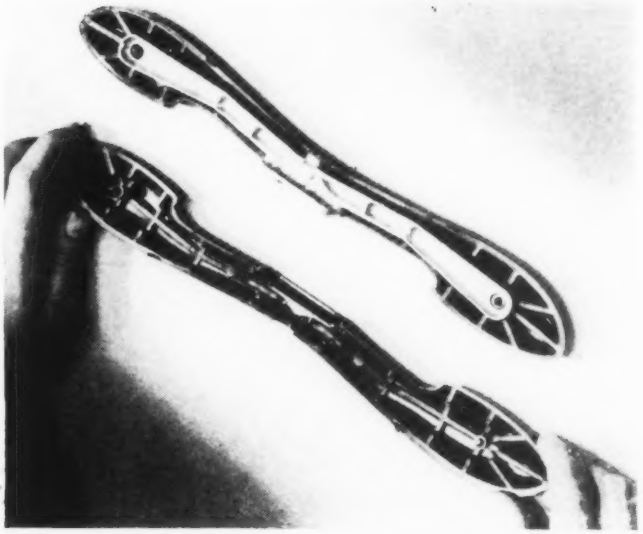
Temperature: Tropical sun to cold as far north as Canada.

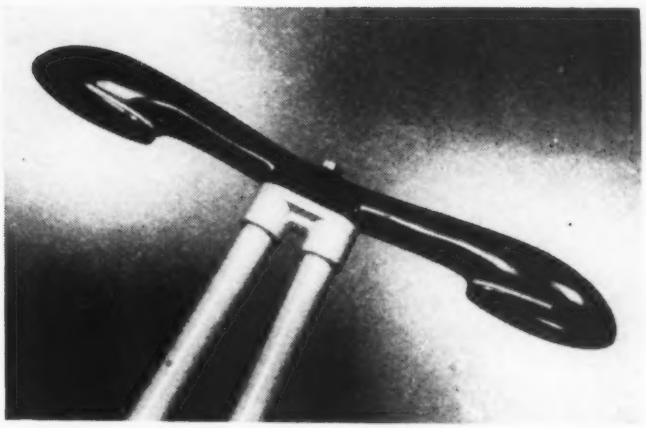
Humidity: Up to 100 percent in the atmosphere, and direct contact, as in mowing the lawn after rain.

The cellulose acetate butyrate molded parts occupy a total of 1.3 lb per unit, or more than 4 percent of the total weight. The five basic parts add up to a total of 17 separate parts in the mower.

Tennessee Eastman Corporation

REEL BEARING SEALS molded of butyrate are used for their toughness and nontarnishing properties. They fit snugly over the retainer with finger pressure, are easily removed for servicing. Ball bearings are mounted on a removable bearing plate.





LARGE butyrate handle provides a smooth gripping surface that is unharmed by perspiration or rough use. As shown above, each half of the handle grip has a core of die-cast zinc to which the molded plastic parts are solvent cemented.

. . . Small Electrical Components

Dimensional Stability at Elevated Temperatures is Critical Property

Timing Relays

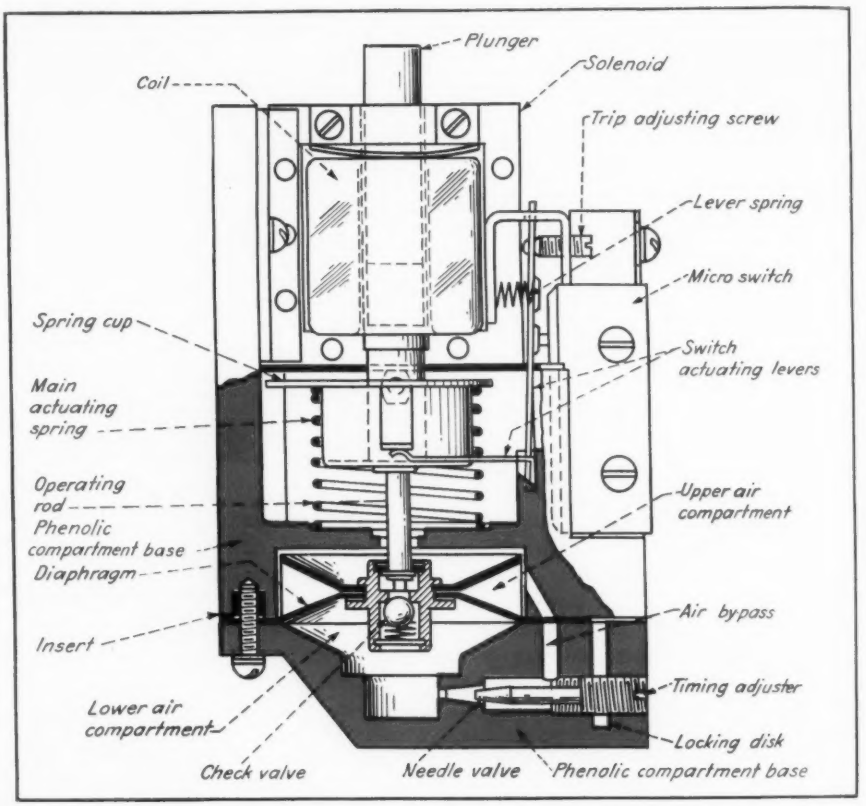
The high dimensional accuracy possible when a phenolic plastic is skillfully molded can be seen in the new Cutler-Hammer pneumatic timing relays. Molded of a phenolic compound (Durez), the two molded parts act as a dielectric base for the electrical components of the relay. In addition, they contain two air chambers, a seat for the needle valve which controls the timing, and an air bypass hole. Thus efficient operation of the relay depends on the ability of the phenolic plastic to be molded to close tolerances and to hold these tolerances, as well as on dielectric properties.

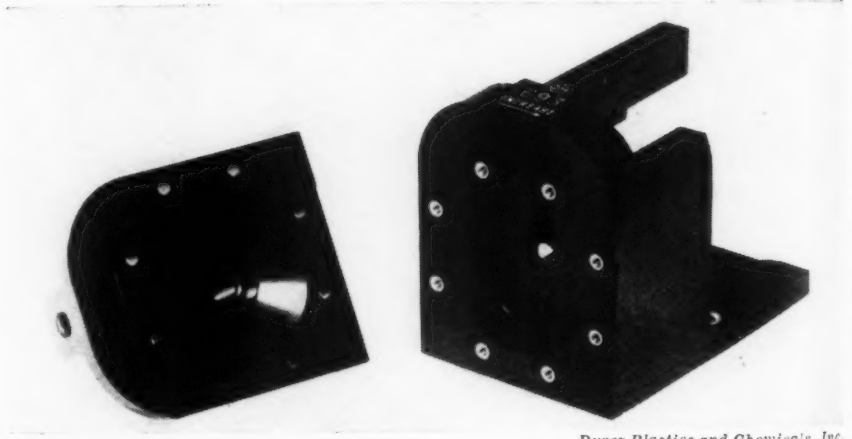
The timer consists essentially of two air compartments connected by a check valve and a by-pass, a diaphragm, a solenoid and spring assembly to actuate the diaphragm, and either one or two micro-switches.

A spring then exerts a force through an operating rod on the diaphragm which is mounted between the upper and lower air compartments. This diaphragm, which has a ball check valve mounted in its center, is held in place between the two molded plastic sections. Eight molded-in threaded inserts (see accompanying illustration) assure adequate pressure between the two parts to hold the diaphragm in place and make the joint air tight.

As the diaphragm is raised by spring pressure into the upper chamber, the air is forced through a bypass hole drilled into the chamber at an angle. When the two parts are assembled, this hole matches a second molded-in vertical hole in the lower piece. This in turn enters a horizontal threaded hole with a tapered end which opens into the lower chamber. An adjustable needle valve is fitted into the threaded hole. Therefore, by adjusting the needle valve, the time required for the diaphragm to rise can be varied from 0.3 seconds to 3 min.

As shown in the accompanying illustrations, both plastic parts are of intricate design. The large piece embodies eight blind threaded holes and nine through holes as well as many inserts, bosses, and other irregularities. By transfer molding this part and using threaded inserts, only a grinding and four drilling operations are required to make the part ready for assembly. The smaller part has ten through holes, an intricate 2-part threaded hole which tapers to a pinhole at its end, and two deep cavities; molding produces a part which requires only one grinding and one drilling operation to complete. The phenolic material is its own insulator, creating additional savings of weight and space. The overall size of the new timer is approximately $4\frac{7}{8}$ in. high, 3 11/16 in. deep and $2\frac{3}{4}$ in. wide. The device is accurate to plus or minus 10 percent of the mean timing period, and is applied on machine tools, conveyors, and a wide variety of automatic processing equipment.





Durez Plastics and Chemicals, Inc.

TWO MOLDED phenolic compartments form main structure of pneumatic timing relay. Of intricate design, the plastic parts contain many blind threaded holes, inserts, bosses and other irregularities. Insulating properties of plastic save weight and space.

Motor Protector Thermostats

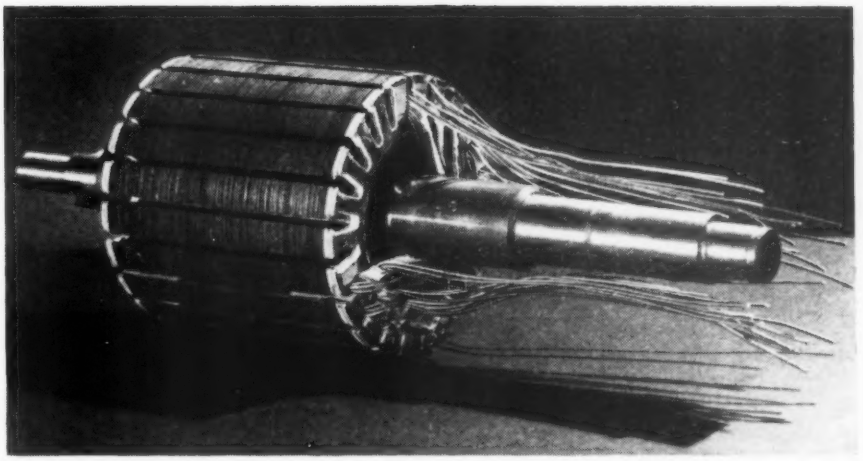
IN AUTOMOTIVE, aircraft, and refrigerator applications, a motor overload protective device, based on temperature, is an exceedingly important component. Many such parts are made by the Spencer Thermostat Company, Attleboro, Mass. Such units must retain dimensional stability in a temperature range from 140 F to 450 F.

After experimenting with various inert-filled heat-resistant thermosetting materials, which proved unsatisfactory, a special heat-resistant phenolic (BM-13335) was chosen. Not only was superior heat resistance obtained, but as can be seen in the illustration below, a high gloss is retained after prolonged heating. This compound is also more easily molded than many other heat resistant formulations, and has a lower specific gravity.

Uniformity of properties and dimensional stability at high temperatures is demonstrated in a series of tests on thermostats which are designed to operate ("trip") at various temperatures, from 246 to 260 F. After repeated cycling—consisting of baking the units at 450 F for 72 hr. and then cooling—these units maintained their tripping temperature to within plus or minus 0.5 deg. Fahrenheit.

Bakelite Corporation

INTRICATE bimetallic contacts, held in place with force-fit clips, makes a further claim on dimensional stability of the phenolic heat control units.



END LAMINATION on a mine motor armature is low pressure laminated of a glass-polyester resin combination. These have been found superior to conventional materials because of easy fabrication qualities and excellent physical and electrical properties.

Motor Parts of Glass-Polyester Laminates

MANY heavy duty electric motors must operate at relatively high temperatures, therefore require insulating parts having high mechanical properties in addition to basic electrical insulating properties. Fiberglas reinforced-polyester plastic laminates, one type of which is manufactured by Laminated Plastics, Inc., Cleveland, are being widely used by electric motor manufacturers in applications of this kind.

A typical example is the end lamination on a mine motor armature made by Reliance Electric and Engineering Company, Cleveland. In this armature the coil windings turn tightly around the ends of the armature slots, and special precautions must be taken to insure proper insulation at the point where the coil leaves the armature slot and bends sharply around to enter an adjoining slot. To protect against a "ground" or short circuit at this point, laminations exactly like the steel laminations, but punched from the glass-polyester laminate instead, are assembled at each end of the armature.

The plastic insulating material used for these end laminations must meet many discriminating requirements:

1. It must handle easily in the punching operation. These laminations are blanked from flat sheet stock with the same tools used for blanking the steel laminations.

2. These end laminations must not chip or break during assembly of the armature coils. A considerable amount of pressure is exerted on the individual fingers of these laminations during bending and hammering the heavy coil windings into place. The plastic laminations must be hard, so they will not flow or bend out of position under pressure of the sharp bends.

3. In operation these armatures spin at speeds up to 3,000 rpm, under considerable mechanical abuse and vibration. The centrifugal force of the copper wire coils tends to throw them out of the retaining slots in the armature and the plastic laminations must be strong enough to resist these forces.

4. The physical requirements placed on these end laminations are made many times more difficult by the fact that the armature must operate at elevated temperatures, up to 120 C (250 F) and occasionally 135 C. Thus, the end laminations must retain all of these physical properties at this high temperature.

Important characteristics of this laminate are its unique combination of good resistance to elevated temperatures and good machinability, together with high impact and flexural strength values, good resistance to delamination, and low moisture absorption.

As insulating panel stock, the laminate will stand long exposure to high temperature without embrittlement or blistering. It resists tracking well. For instance, a 1000-volt arc drawn over the surface will produce a carbonized area only about $\frac{1}{8}$ in. wide. This area will conduct current only poorly and without following any def-

Approximate Cost of Electrical-Grade Laminates

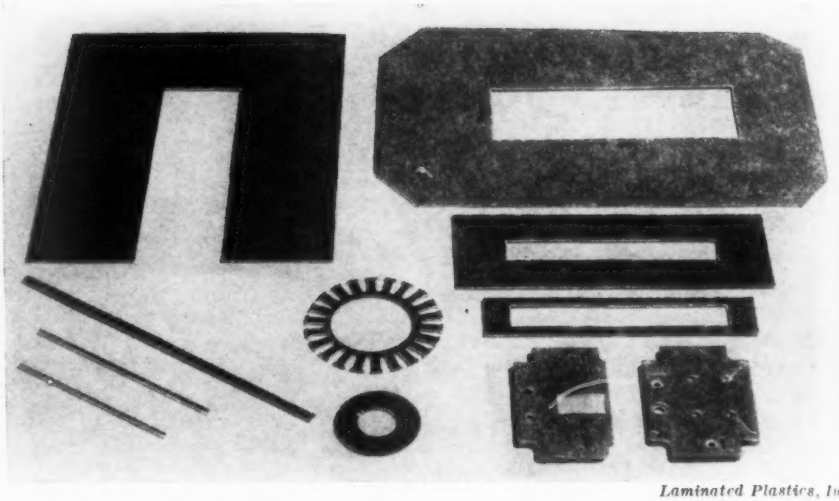
(In order of increasingly optimum heat resistance-electrical properties)

MATERIAL	DOLLARS PER POUND
Paper-base phenolic	0.75
Canvas-base phenolic	1.10
Glass-base phenolic	2.00
Glass-base polyester	1.70
Glass-base melamine	4.00
Glass-base silicone	15.00

inite track. The carbonized area will be "on" rather than "in" the material and can be removed by wiping with a cloth, thus restoring the original surface characteristics.

The laminate is well suited for use as slot sticks, because of its ability to retain its physical properties at high temperatures. Strip stock can be cut with ordinary shears, and the edges of the slot sticks can be chamfered with conventional chamfering tools; or in repair shops, with ordinary hand tools. The slot sticks can be driven into armature coil slots without spreading the ends of the sticks, and without risk of snapping caused by buckling.

These laminates are available in thicknesses from 1/32 to one in., and in sizes from 12 by 18 to 36 by 42 in.

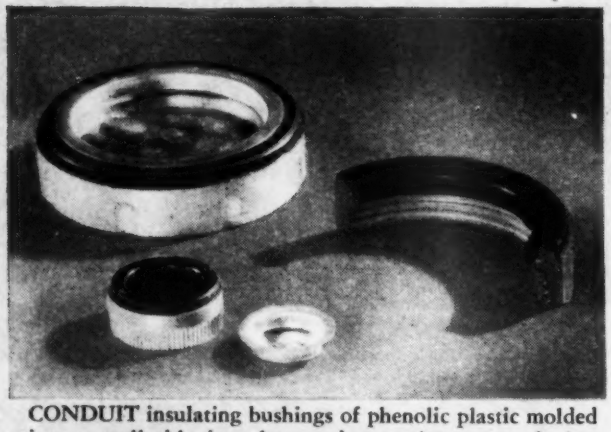


Laminated Plastics, Inc.

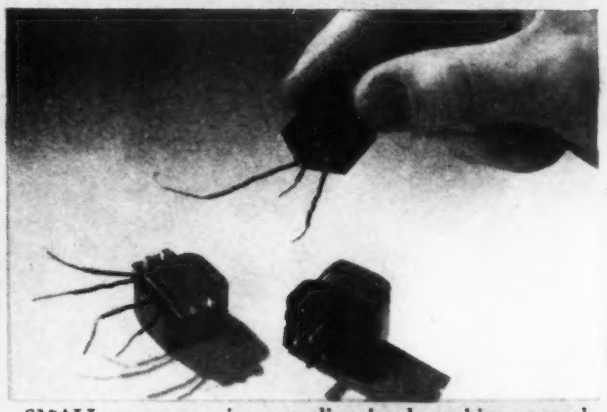
WIDE VARIETY of shapes can be fabricated from electrical grade glass-polyester resin laminate. Typical applications include switch washers, control switch plates, field coil end washers, armature slot stick and end laminations.

Molded Plastics in Small Electrical Parts

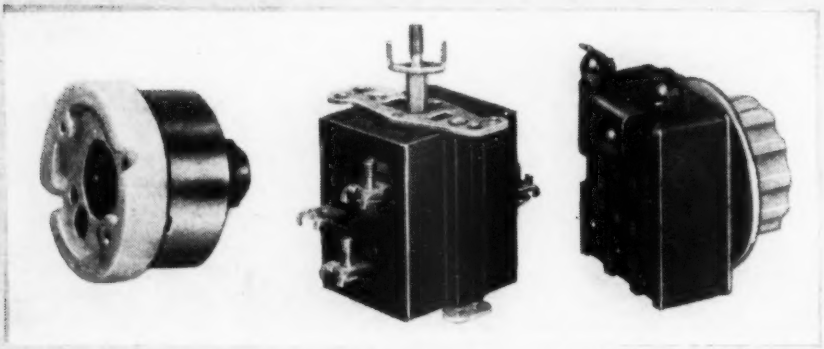
Bakelite Corporation



CONDUIT insulating bushings of phenolic plastic molded into a malleable iron base reduce maintenance of electrical circuits because smooth edges eliminate shorts.

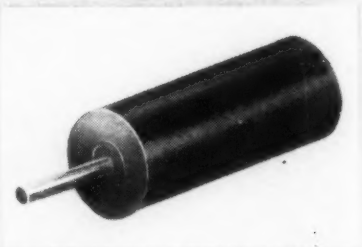


SMALL, compact wire recording head combines record, playback and erase features. Molded phenolic case parts permit controlled pole piece spacing below 0.001 in.

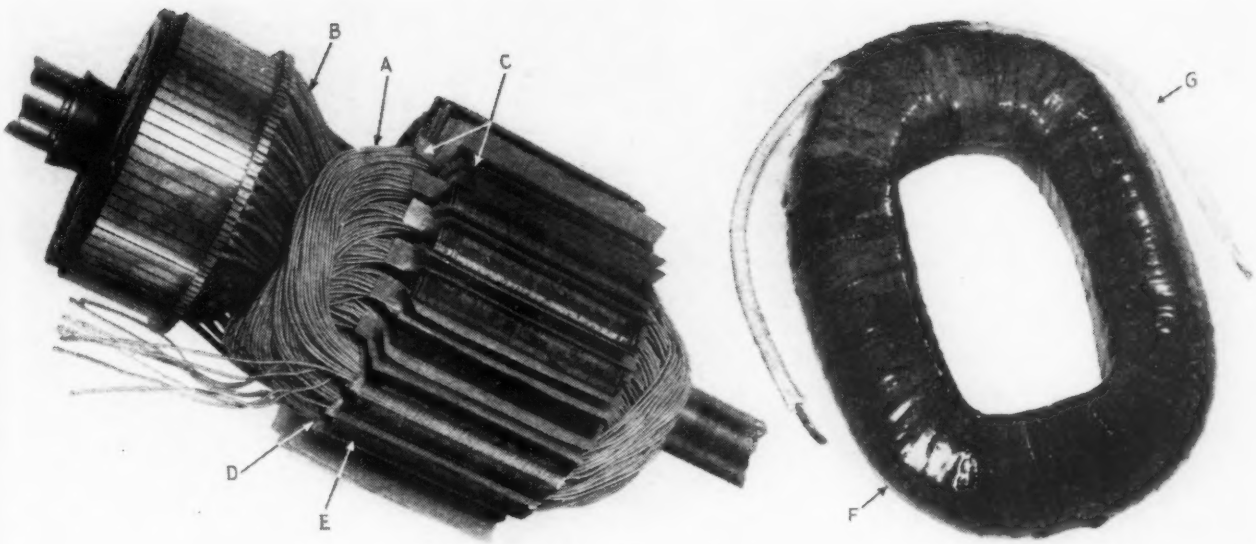


American Cyanamid Company

REDESIGNED electric stove switch (right), molded of melamine plastic, replaces former designs using porcelain (left) and phenolic (center). Tests indicate that this material has sufficient arc resistance and non-inflammability.



ACTUATING PIN in water-level control device for an automatic washing machine is molded of a phenolic plastic. Tiny lathe-turned insert is molded in by Kurz-Kasch, Inc., Dayton, Ohio, for the Special Devices Division of the Magnavox Company.



Dow Corning Corporation

TYPICAL SILICONE insulated dc armature (left), showing: (A) Silicone resin bonded glass fiber wrapped magnet wire; (B) Silicone varnish impregnated glass fiber sleeving; (C) Coil and slot liners of silicone varnished glass cloth or a glass-mica-glass silicone bonded composite; (D) Slot wedges, silicone-glass laminate; (E) Armature impregnated with silicone electrical insulating varnishes; (F) Typical dc motor field coil fabricated with glass wrapped silicone bonded magnet wire, taped with untreated glass tape, and impregnated with silicone electrical insulating varnish; (G) Leads are silicone rubber covered, glass braided wire. For permanent lubrication and motors operating at high temperatures, bearings are lubricated with silicone grease.

. . . Insulation-Electrical and Thermal

Silicone Insulating Varnishes and Molding Compounds Increase Capacity Ratings, Protect Motors

SILICONES have come a long way from the novelty "bouncing putty". It is natural through their inherent chemical composition, that they be used as insulating materials. In the electrical field, where their acceptance has been most rapid, they are valuable for heat insulating as well as electrical properties.

The advent of silicone resins is an important step in insulation development. When used in combination with inorganic materials such as mica, asbestos and glass fibers, the unusually high thermal resistance of the silicones can be utilized in electrical machinery in three ways:

1. To reduce the size and weight of equipment through increase in operating temperature.
2. To permit operation in a high ambient temperature.
3. To obtain increased insulation service life where it is desired to maintain conventional size, weight and temperature.

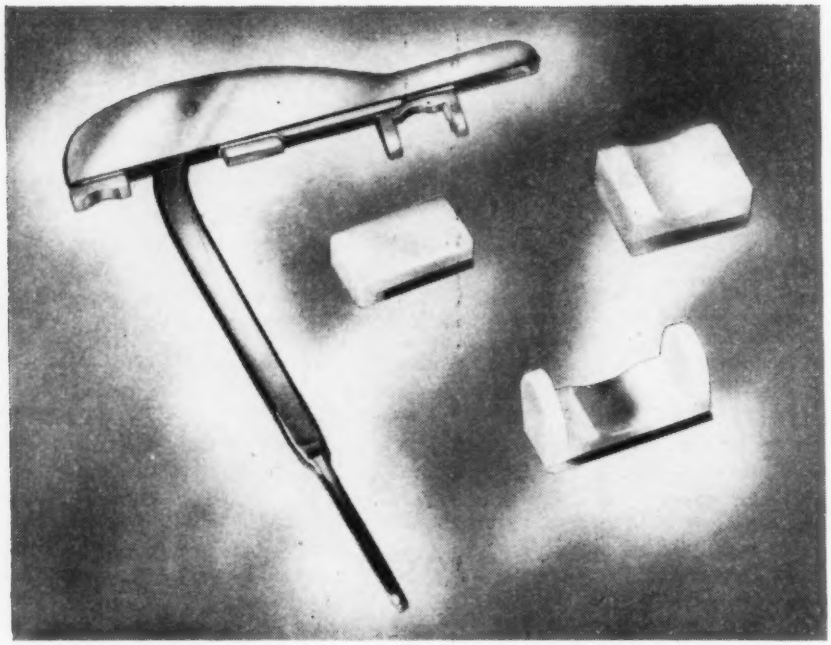
The development of silicone varnishes has resulted in a class of essentially inorganic insulation for electric machines which is more heat and moisure resistant than any insulating materials previously available.

Motors wound with silicone insulation have been raised in rated operating temperature from 105C to 210C. While this is desirable, it has brought with it several problems. One is the problem of the motor protector thermostat.

As discussed on page 137, a heat-resistant phenolic compound serves as the base of such a protector up to 300 F. But in silicone-wound motors (not numerous at present, but being applied to a greater extent) that operate between 200 and 300 C, such a compound would not be satisfactory. Therefore, the Spencer Thermostat Company has molded motor protector thermostats of silicone-glass fiber molding compound made by the Dow Corning Corporation, for use with silicone-insulated motors, or for temperature requirements above conventionally insulated (Class A and Class B) motors.

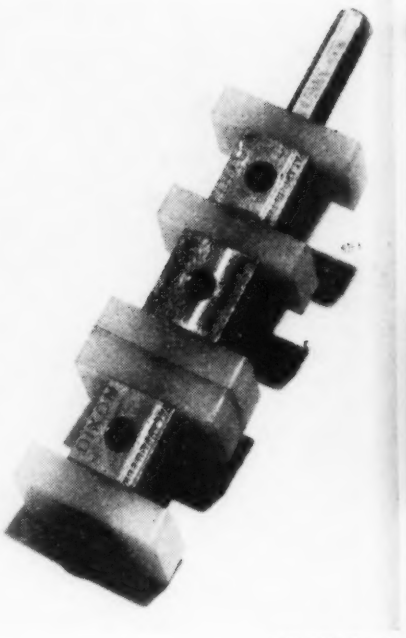
At present the disadvantages of this silicone molding compound are mainly ease of production and cost. Time in the mold is usually 1½ hours, compared with 1 to 2 minutes for phenolics. Although cost is higher than conventional plastics, it is felt that this is outweighed by the property advantages gained.

FOR TEMPERATURE requirements above those of conventionally insulated motors, motor protector thermostats are molded of a glass fiber-silicone resin compound. These serve motors that operate up to 300 C.



Dixon Lubricating Saddle Company

TEXTILE INDUSTRY has been quick to adopt nylon bearings because of their non-lubricating feature, which results in a two-fold cost saving. Lubricating saddles for long draft spinning machines incorporate three nylon bearings, replacing brass. The plastic parts outwear the metal by far. An additional saving is realized, since many yards of yarn were formerly ruined by lubricating oils.



Atlantic Plastics

CAP bar nebs, used with lubricating saddles, provide an oil-free drafting unit that eliminates roll scoring, reduces lint accumulation and lowers average power consumption. Nebs guide top rolls on spinning frames.

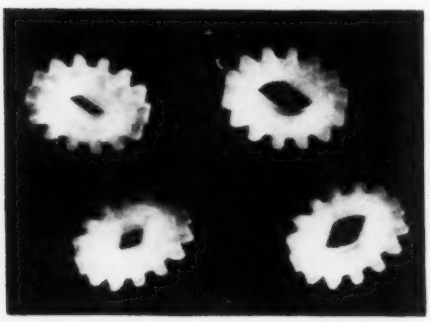
. . . Bearings and Gears *Molded Nylon Parts*

Require no Lubrication and Outwear Metal

EVER SINCE nylon was introduced as a molded plastic (see PRODUCT ENGINEERING, December 1946, page 103) it has been accepted as a "natural" bearing material.

The fact that it will outwear brass and requires no lubrication has made nylon of intense interest in the textile field. In addition to frequent replacement, the use of oil on conventional metal bearings was very costly, since many yards of woven textiles would often be ruined. A good example of such an application is a lubricating "saddle" used on textile spinning frames, manufactured by the Dixon Lubricating Saddle Company, Bristol, R. I. Sold under the tradename of "Slixonice" the bearing surfaces of these saddles are injection molded of nylon by Atlantic Plastics, Inc., Flushing, L. I., N. Y. When made of brass, these saddles were lubricated every 24 hours. Use of nylon also enabled redesign of the saddle for more efficient performance.

As an idea of what elimination of lubrication means, it should be noted that an average spinning frame has 252 spindles; since there were 27 places to lubricate in an average spinning frame. It has been estimated that this saves 18,900 man hours per week in an average mill of 20,000 spindles.



Ranger, Inc.

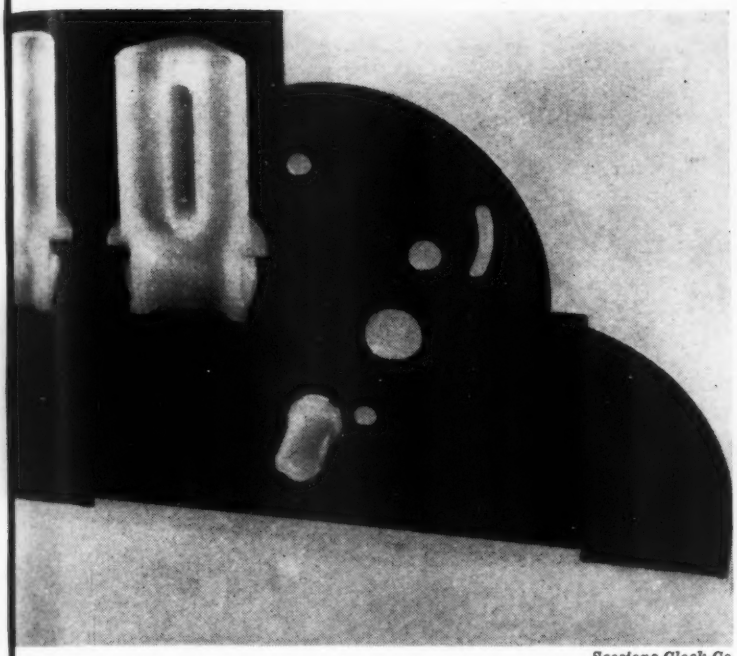
SMALL molded nylon gears show promise for timing functions. Used in a fishing reel, these gears were tested continuously for 400 hr at 2200 rpm, with no wear.

Small Timing Gears

Gears, like bearings, offer the problems of lubrication and wear. In many applications, such as food mixers and inaccessible mechanisms, lubrication is undesirable or impossible. For automatic timing devices, a gear that does not require lubrication is often a necessity—this is true in military applications such as guided missiles. In such applications, molded nylon is proving to be the only satisfactory material.

An actual nylon timing gear is being molded by Atlantic Plastics, Inc., for a fishing reel manufactured by Ranger, Inc., Rockford, Mich. These gears are surface hardened by a special heat treatment, or sometimes by modifying the molding process. Other peacetime applications of nylon timing gears include windshield wipers, food mixers, and other sealed mechanisms.

Some idea of the toughness and abrasion resistance of these nylon gears can be gained from the results of tests conducted by Ranger, Inc. (Their size can be estimated from the fact that they are used in fishing reels.) In breakdown tests run on the reels themselves, it was found that these gears will withstand at least 400 hours of continuous operation at a speed of 2200 rpm, without any adverse effect on the nylon gear. It should be noted the tests were discontinued after 400



Sessions Clock Co.

CONNECTOR LEADS for back plate of electric clock are injection molded of nylon. The two parts are assembled by a snap fit. In addition to its insulating function, the lead acts as a strain-relief bushing, preventing shock to the inner mechanism by a sudden yank on the electric cord. Dielectric strength is 4 times the Underwriters' specification of 900 volts.

Du Pont Company

USE of a strain-relief bushing made of nylon allows this heavy radio to be lifted by the attached wire without danger of severing delicate connections. The bushing is simple in design and has the Underwriters' approval for household electrical appliances.

hours only because the product being tested was a fishing reel.

According to officials of Ranger, Inc., these are the reasons for adopting molded nylon gears:

1. Greatly lowered cost per part.
2. No lubrication required.
3. Silent operation.
4. Molded gears show a much smaller variation in quality and tolerance than cut gears.
5. Longer life than maximum requirements.

Bushings

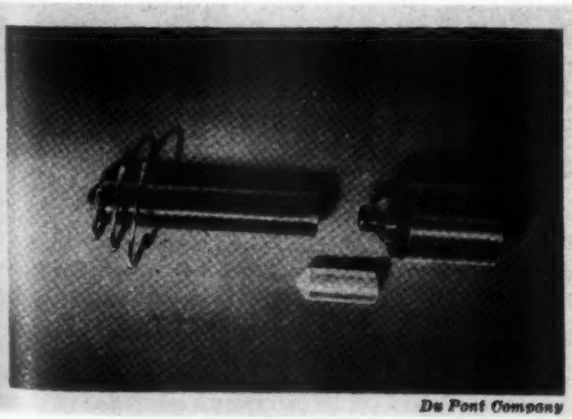
Nylon is also answering the bushing problem through its use as connector leads and strain-relief bushings. Shown in the accompanying illustrations are nylon connector leads molded by Atlantic Plastics for the Sessions Clock Co., Bristol, Conn. The leads are injection molded in two parts which are assembled by a snap fit.

This represents an unusual molded piece, since undercuts of 0.0075 in. were required on each side and at each end. The lead, which fits into a hole in the metal back plate of an electric clock, performs the following functions: (1) Provides insulation of the wires against the metal plate; (2) clamps the wires tight—these units are subjected to a 30 lb dead weight pull by the Underwriters Laboratories; (3) prevents the clockworks from being pulled out; and (4) withstands the heat of wire soldering.

Molded of FM-10,001 nylon, (formerly FM-1) this material has excellent tensile strength, abrasion resistance, is non-inflammable and has a dielectric strength of about 4 times the required Underwriters specification of 900 volts.

Wheel Bearings

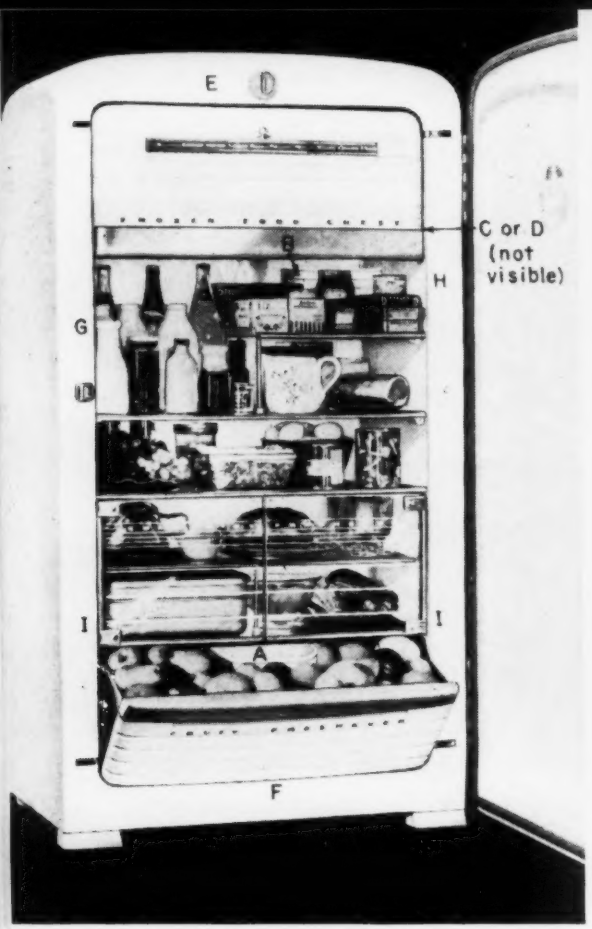
Possibilities of nylon as wheel bearings have been demonstrated by the Collier-Keyworth Co., Gardner, Mass., baby carriage manufacturers, who have subjected nylon bearings to rigorous testing before adopting them. In one test a carriage wheel was turned for the equivalent of 1190 miles with the axle in a vertical position so that the bearing was in constant contact with the axle shoulder. Although the metal axle was slightly worn, bearing wear was negligible. In another test the wheel box was loaded with sand, sealed and revolved for the equivalent of 353 miles, with no bearing wear.

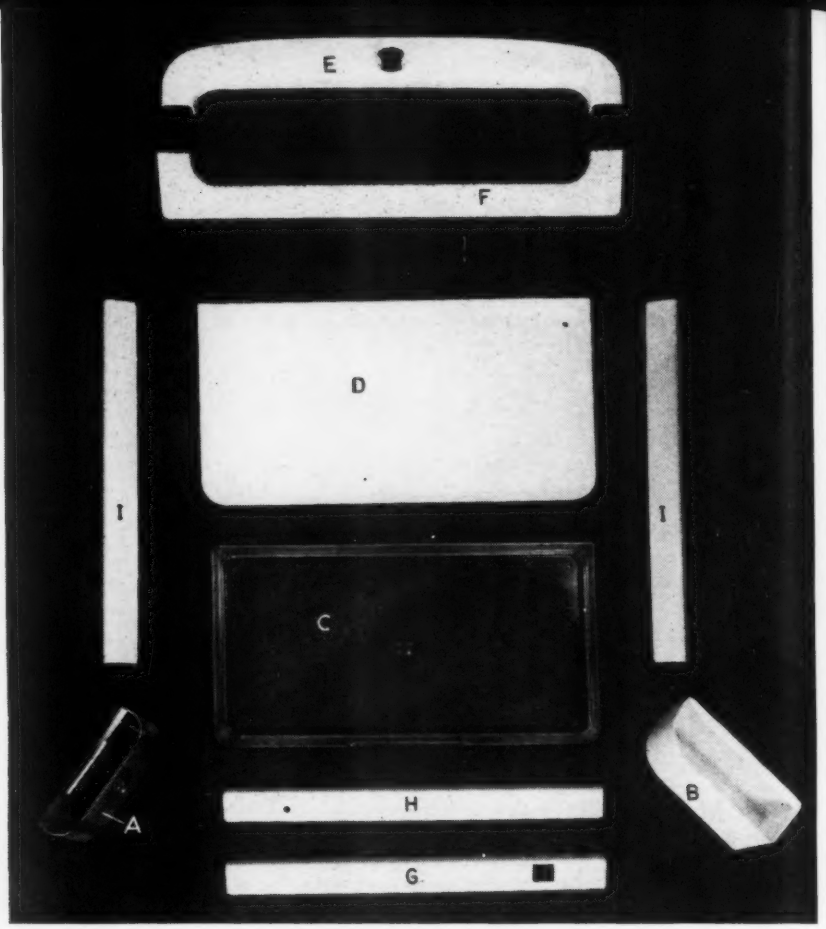


Du Pont Company

Speaking of Nylon . . .

Nylon is also serving where accurate gasketing is important. Shown here is a tiny nylon insert, 7/32 in. long and 0.107 in. in diameter, which serves as a valve seat in an air-flow regulator in inhalation oxygen equipment. The valve plug containing the nylon insert throttles down the flow of air to the bellows assembly and helps maintain constant pressure. Nylon was chosen because it had the unusual combination of properties required for that job: Toughness, resiliency, compressive strength, resistance to oxidation, freedom from adhesive tendencies, and the ability to be molded to close tolerances.





GREATER USE of plastic parts than ever before is shown in the new Kelvinator refrigerator. All of these parts are injection molded of polystyrene: (A) Drip receptacle, formerly made of glass or metal; (B) defrost receptacle; (C) one-piece baffle, to separate evaporator from warmer food compartment, previously made of metal or paper-phenolic laminates; (D) two-piece insulated baffle (either C or D used); and trim provision compartment parts; (E) top, (F) bottom, (G) strikeside, (H) hingeside, (I) right and left sides. These parts were formerly made of painted phenolics or metals, and polished stainless steel.

. . . Refrigerator Parts

Use of Polystyrene and Large-Section Molding is Trend in Refrigerators

A POPULAR misconception is that polystyrene is used only because of its low cost. Nothing can be further from the truth. Polystyrene has its own distinctive special properties, just as the phenolics and the acrylics do; it is for these properties that polystyrene is being applied in so many products. One field where polystyrene seems to be gaining increasing importance is in the manufacture of refrigerators. From a modest start, a point has been reached where one manufacturer of refrigerators, the Nash-Kelvinator Corporation, Detroit, Michigan, uses nine different parts molded of polystyrene. The function and relative size of each of these parts is explained in the captions under the accompanying illustrations.

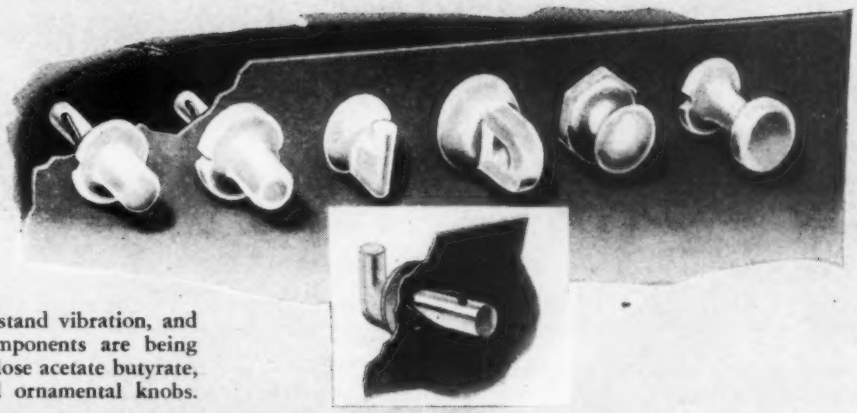
In examining these parts it becomes apparent that only polystyrene could have fulfilled the peculiar combination of properties required in refrigerator manufacture. Most of these parts must operate at temperatures ranging from 25 to 45 F, and at relative humidities from 65 to 85 percent. Polystyrene is one of the few plastic materials that can withstand continuous exposure to such conditions, and still retain its dimensional stability. It is interesting to note that, in this application, polystyrene replaces glass, metal, and paper base phenolic laminates.

The second important reason for using polystyrene is that it can be injection molded in extremely large projected areas. The evaporator door weighs twelve ounces and has a projected area of 120 sq. in. The one piece baffle, which separates the cold area in the evaporator from the warmer food compartment, is an even larger molding, and runs the entire width of the refrigerator. Nash-Kelvinator has established its own plastics division in Milwaukee to do most of the molding. It molds all of the sides of the trim provision compartment—top, bottom, strike side, hinge side, and right and left sides—of Dow's Styron 666. The other four parts are molded of polystyrene by custom molders for Kelvinator.

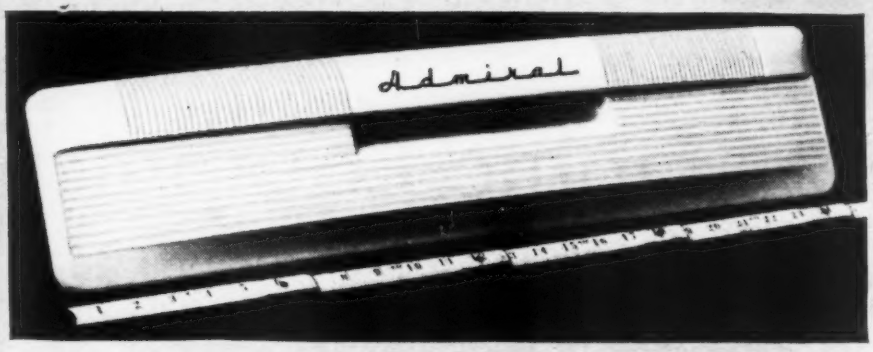
Thermoplastic Sheet Possibilities

Just as the rapid forming of sheet steel revolutionized production from machined castings to finished-size stampings, so the fabrication of sheet plastics promises equally new fields of application.

In a new process, instead of sheet stock, molding power, sometimes with core material, is compression molded



REFRIGERATOR shelf supports, molded of polystyrene, have recently been developed by the Simmons Fastener Corporation, Albany, N. Y. Complementing metallic supports of the same type, these supports lock and unlock with a quarter turn. They contain steel inserts for greater strength. As shown in the illustration, the spring wire, which is twisted at installation, provides high torsional strength to withstand vibration, and enables quick assembly. Similar components are being developed of ethyl cellulose and cellulose acetate butyrate, for automobile dashboard plugs and ornamental knobs.



THE Admiral refrigerator freezing unit door, weighing 14 ounces, is molded of polystyrene by MacDonald Manufacturing Company on a 16-ounce Improved Paper Machinery Corp. injection press, using a 45-second cycle.

into a laminate or thermoplastic sheet. This is a blank that is determined by shape and size of the finished part. The sheets are heated to forming temperature and then placed in a die to be drawn to the required shape. The properties of the finished product also determine the resin that is used.

Woodall Industries, Inc. of Detroit, Michigan are now hot forming sheets of polystyrene for a refrigerator baffle which separates the freezing compartment from the cold section.

Use of sheet plastic extends the field to which these plastics can be applied, and is not a substitute for molded plastics. In fact, molded polystyrene plastic stiffeners are inserted in the assembly to take the screws which attach the meat compartment guide rails to the bottom of the baffle plate.

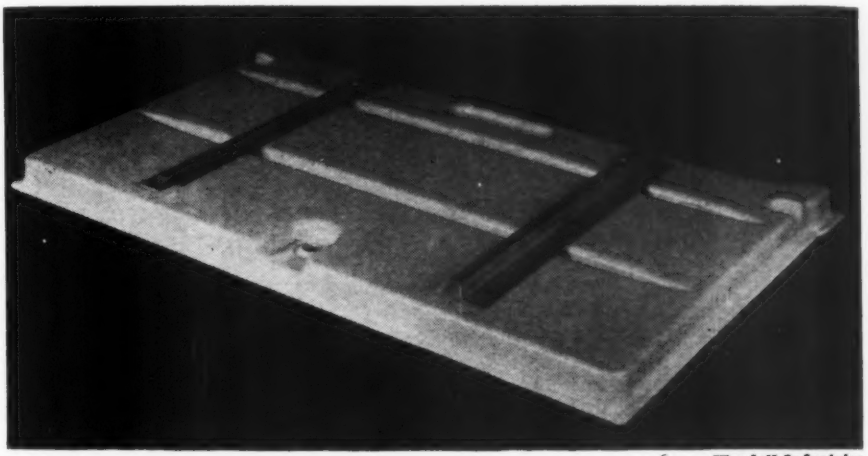
Polystyrene was chosen also because of its dimensional stability, its extremely low moisture absorption, and because it is non-corrosive and has a high heat insulating value.

The present size limitation of this Woodall process is the dimensions of the plastic sheet, which are 37 x 57 in. For the part shown, the thickness is about 0.093 in., and this is uniform over the whole sheet. Parts formed from these sheets are unusually stable in dimension and form because the original sheets are made strain free.

A simple cast iron die is used to form the parts. The sheet to be formed is clamped between the die and the pressure plate and air applied from above to make the sheet conform to the die. Air is applied to the finished or exposed surface so there will be no die marks on it. This gives a high lustre finish. Deep draws and lettered instructions are molded into the sheet by this process.

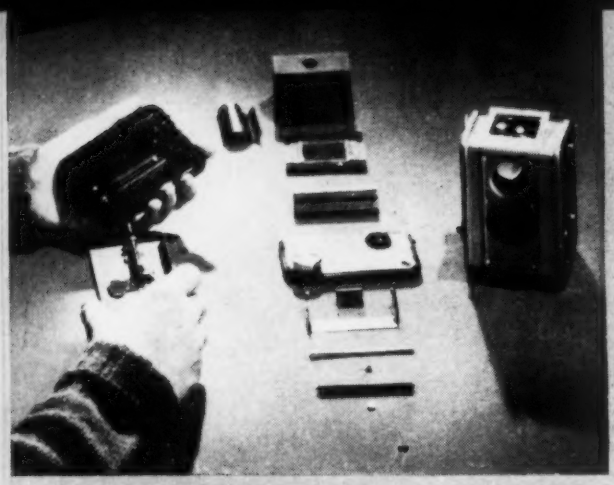
The baffle is a composite piece having top and bottom elements formed from sheet plastic with a Fiberglas insulating pad between them. They are sealed together with an adhesive made from polystyrene and a solvent. Two molded polystyrene brackets are inserted to take the screws which hold the metal rails on the bottom of the baffle.

The baffle shown in the accompanying illustration is part of a production lot made for Crosley by Woodall. However main production of the Crosley refrigerator baffle is by injection molding. The large injection-molded Crosley baffle has a projected area of 367 sq. in. and weighs 5.1 lb. Ribs, bosses and decorative curves are molded in.



Woodall Industries

COMPLETED BAFFLE, consisting of two parts which are hot-formed from polystyrene sheet. Metal rails are attached to the bottom with Phillips-head screws. Overall dimensions: 25 in. long, 16 in. wide and 1.125 in. thick.



1 Basic assembly of the Kodak Duaflex camera body is made up of these sub-assemblies. Assembly commences with the joining of the shutter sub-assembly and the left panel. Camera is 2¼ x 2¼ reflex-type.

2 Left panel, injection molded of black polystyrene. Note the molded-in grooves which enable the operator to fit the parts into the proper position.

3 Close-up showing how the stamped metal shutter subassembly is fitted into the Duaflex camera's panel. Grooves hold the parts in place.

. . . Photographic Equipment

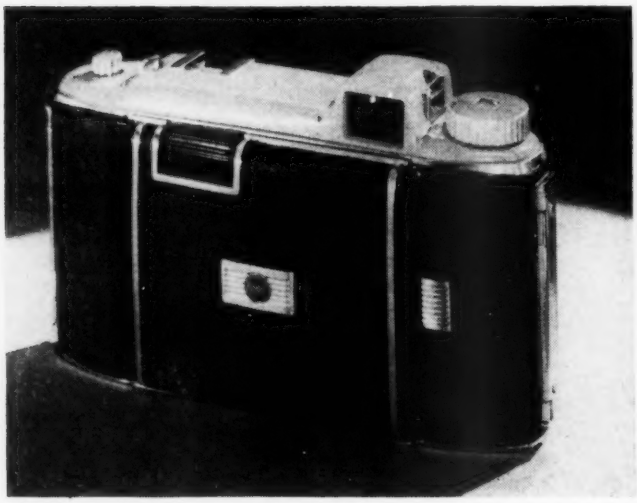
Redesigned Cameras Improve Appearance and Performance Through Heavy Use of Plastics

A CAMERA is a product that makes the most exacting demands on the skill of the design engineer. Not only is surface appearance extremely important, but parts must fit together precisely for efficient performance—hence dimensional stability and resistance to moisture, chemicals and aging are basic requirements of the materials used.

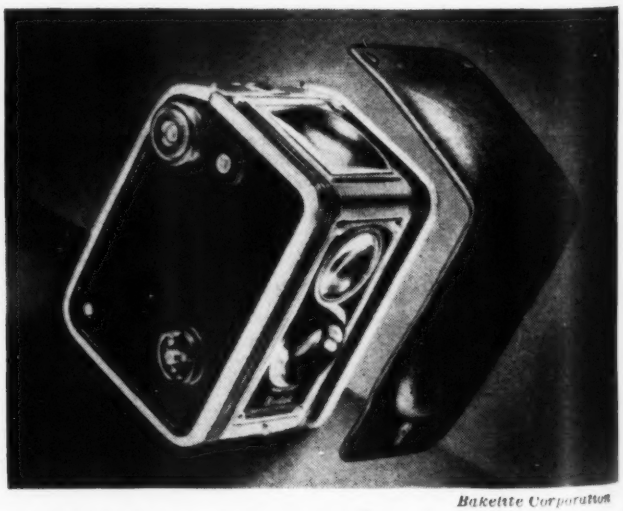
The Kodak Duaflex camera, a relatively inexpensive new reflex-type camera makes use of polystyrene for one of its basic parts. Production costs of this camera have been radically reduced through the use of sub-assemblies, and stamped metal parts. These sub-assemblies include:

1. The sheet aluminum back.
2. The shutter.
3. The front—made of sheet aluminum.
4. The winding key.
5. The spool center bracket.
6. The side panel—made of polystyrene—designed to align and support all other sub-assemblies.

Originally it was intended to produce the camera with aluminum side panels as well as aluminum front and back plates. As proposed, these aluminum side panels would have been painted black. However, cost estimates and other considerations changed the plan. As a result, black polystyrene (supplied by Dow Chemical Co.)—injection molded in a multiple cavity die—was selected for the sides. Where it was necessary to locate a



VIEW FINDER HOOD of Kodak Tourist camera is injection molded of cellulose acetate butyrate, in two parts. In addition to forming the top cover of the camera, the unit acts as a holder for accessories. It also facilitates assembly of view finder optics.



Bakelite Corporation

LENS COVER for redesigned Kodak Duaflex camera (described above) is molded of polyethylene. The lens shield protects both the finder and objective lenses of the camera. The polyethylene lens shield takes the place of a case.

4 Lower wall housing which protects the film—except the area to be exposed—is inserted into slots in the camera's side panel.

5 The camera's right side panel (molded polystyrene) is added. The parts already inserted in the left side panel fit into grooves in the right side panel.

6 The single threaded tie rod that holds the camera assembly together is inserted. Tie rod and a single nut hold the camera together. Time required for this assembly is about two minutes.

rivet in the panel, the rivet was barreled to accommodate the cold flow characteristics of the plastic. The molds for the left and the right panels contain eight cavities each.

Photographic Accessories

Use of cellulose butyrate has been expensive in auxiliary units, as shown in the accompanying illustration. The view finder for the Kodak Tourist Camera is injection molded of butyrate in two parts. This unit has three important functions in the camera:

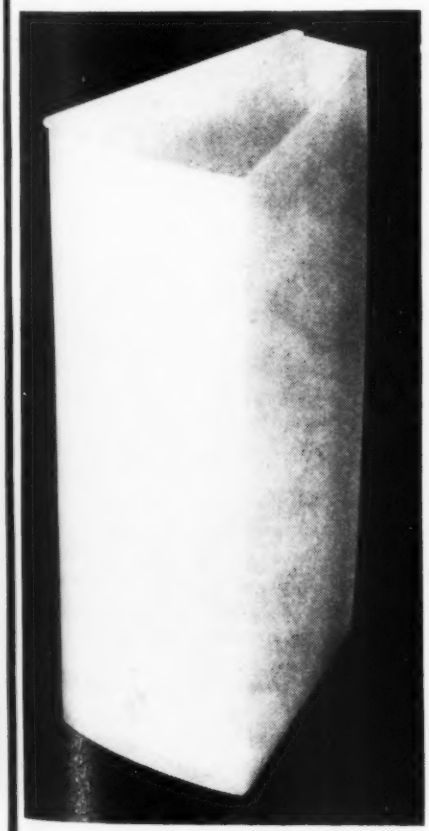
1. Allows for easier assembly of view finder optics.
2. Forms the top cover for the complete camera.
3. Acts as a holder for photographic accessories.

The Kodak flash holder has a battery case molded of black butyrate and a head molded of gray butyrate. The reasons for using butyrate were: excellent impact strength and dent resistance; attractive two color effect; insulation is obtained through the plastic parts, thus saving extra insulation and reducing assembly difficulties.

The Kodak tray siphon has been redesigned in gray cellulose acetate butyrate; hard rubber was formerly used. The hard rubber unit had three parts held together mechanically; the butyrate design calls for two molded sections. The new design permits a more attractive color and considerably reduces the cost of the finished product. It is corrosion resistant, and withstands normal city water pressures.

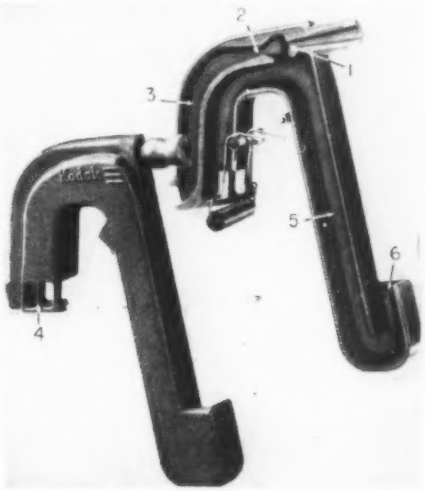
Polyethylene, through its resistance to moisture and chemicals, flexibility and ease of molding, is being adapted to many photographic parts. The protective lens shield for the redesigned Kodak Duaflex camera, described above, is molded of polyethylene supplied by the Bakelite Corporation. As shown in the accompanying illustration, the lens cover protects both the finder and objective lenses of the camera.

Chemical resistance and unbreakability led to the choice of polyethylene for an unusually large developing tank. Shown in the illustration, it is molded by Plastic Die and Tool Corporation, Los Angeles, for use in automatic photo-taking machines made by Auto-Photo Company of Los Angeles.



CHEMICAL resistance and non-breakability led to choice of polyethylene for this photographic developing tank of unusually large dimensions.

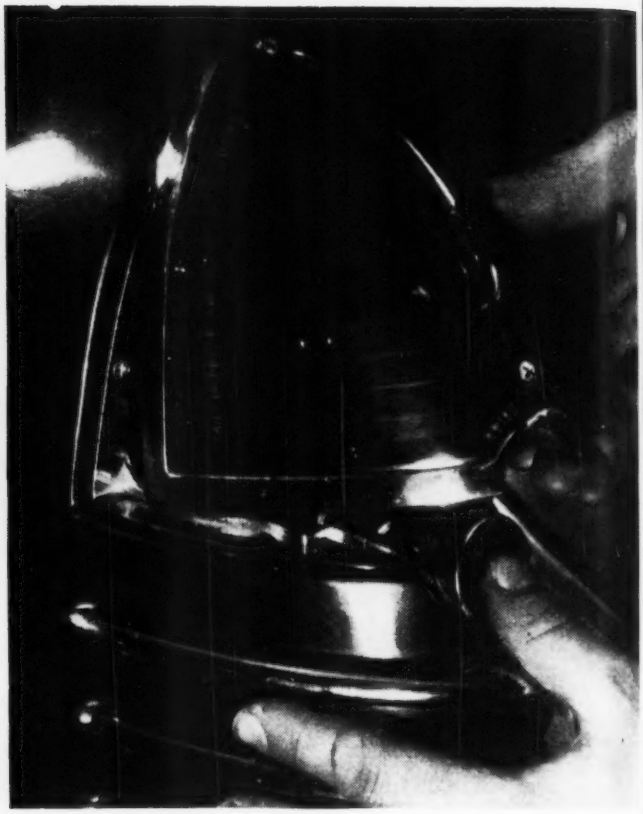
FLASH HOLDER combines two colors of the same plastic: Battery case is molded of black cellulose acetate butyrate and the head is molded of gray butyrate.



TRAY SIPHON of gray butyrate has the following parts: (1) Nozzle; (2) orifice; (3) supply channel; (4) siphon inlets; (5) siphon tube; and (6) outlet.

Tennessee Eastman Corporation

CELLULOSE ACETATE BUTYRATE steering wheels are used on practically every make of leading U. S. motor car. The tough plastic, molded over a metal insert, provides a surface that is pleasant to the touch and is proof against chipping or peeling.



REAR TAIL LAMP on Cadillac, with lens injection molded of a red heat-resistant acrylic plastic, serves as both tail lamp and stop lamp. Acrylics have better weather and age resistance than other transparent plastics, and optical properties are excellent.

. . . Automotive Applications

Emphasis is on Greater Use of Plastics as Functional Parts

PLASTIC MATERIALS have proved their value in automobile construction. According to a member of the General Motors research department, the following kinds of plastics were used in nearly 200 parts of a General Motors car, in the medium price range:

Phenolics	1.3636 lb.
Cellulose acetate butyrate	0.8698
Cellulose nitrate	0.0389
Methyl methacrylate	0.6095
Vinyl polymers	1.2670
Urea formaldehyde	0.0265

Among the larger pieces is the steering wheel, which is molded of cellulose acetate butyrate, around a metal insert. The cellulose acetate butyrate in steering wheels is subjected to laboratory temperature aging tests ranging from —40 F to 180 F. A cyclic program is followed, with a completely molded and finished steering wheel subjected to the following:

24 hr at 175 F dry humidity;
24 hr at —40 F;
24 hr at 175 F at 65 to 70% relative humidity;
and 24 hr at —40 F.

During this aging test the plastic must not crack at any point. The results obtained agree with actual service results and it is now the practice to perform the same tests for routine control of quality in production.

Two mechanical tests are performed on the steering wheel. They are known as a "cantilever" test and an "impact" test.

The steering wheel used in the cantilever test is an aged wheel which has been cooled for 12 hr at —10 F. Mounted on a test fixture at the hub, the wheel is subjected to a 200 lb load applied downward at the rim at right angles to the plane of the wheel. Conditions include: (a) Division of the load at each side of one of the spokes, and (b) concentration of the load at a point on the rim equidistant from two spokes. When there are failures in this test the plastic usually cracks at the point of intersection of the spoke and the hub.

The impact test is designed to determine the ability of the steering wheel to withstand the effects of accidents, without breaking, so as not to injure the driver. In this test the aged wheel is mounted approximately as in an automobile and a 100 lb sand bag is swung from a height of 30 in. Neither splintering nor shattering of the plastic, nor failure of the welds of joints

on the metal inserts of the wheel is acceptable.

Phenol formaldehyde and related materials are molded into distributor assemblies. This resin is also important as an adhesive ingredient in the bonding of brake linings (see article "Industrial Adhesives", PRODUCT ENGINEERING, December, 1947).

An evident trend in the automotive industry is the use of transparent acrylics (methyl methacrylate) for lamp lenses. As shown in the accompanying illustration the rear tail lamp lens on the 1948 Cadillac is injection molded from a red heat-resistant acrylic formulation. The lamp, of which this lens is a part, serves as a tail lamp and a stop lamp. This material has superior weather and age resistance to other transparent plastics, and better impact resistance than glass. Experiments with large size lenses are now being carried on, and it may not be too many years before all other lenses in our automobiles are molded of acrylic plastics.

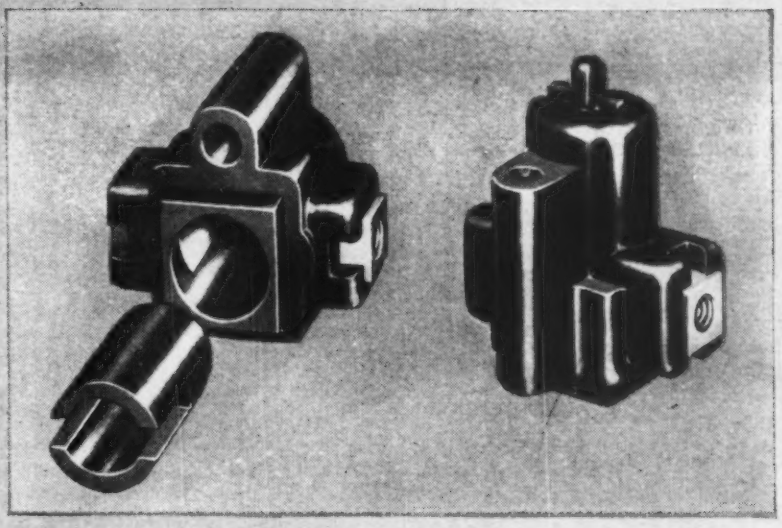
Production costs of truck tail lights have been reduced by the development of a technique for extruding the plastic lens. Made of red acrylic resin, the extruded lens effects savings especially in comparatively small runs. Conventional tail light lenses are injection molded. After extrusion, the strip of plastic for the lens is cut and shaped to fit an aluminum frame. Production can be geared to any volume of manufacture.

The extruded lens has all the advantages of other lenses and reflectors for automobiles made of the same material by different methods. It is weather-resistant, moisture-resistant, and shatter-resistant. It is stable over a wide range of temperatures, has excellent light diffusion properties and is approximately three inches in length, two inches wide, and one-eighth of an inch thick at the thickest point.

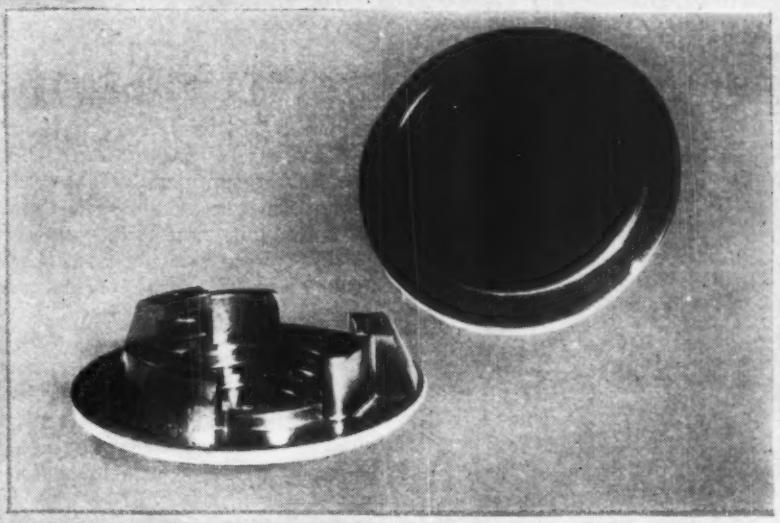
By far the largest use of plastics in the automotive industry is in making paint or lacquer. On the "average" car whose plastics components are analyzed above, it required 80 lb of paint and thinner for the finish. In spite of losses in production, and evaporation of thinner, it is a fact that a car weighs 25 lb more when painted than unpainted.

There is evidence that plastic laminates and other sheet composites will eventually replace much of the upholstery material now used on the interior sides of the automobile.

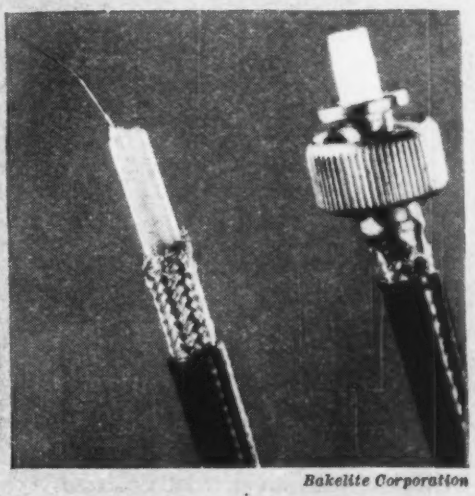
A start in this direction was made in the use of low pressure laminates on the interior of the DeSoto Suburban station wagon (see "Recent Developments in Plastics and Rubber", PROD-



UNUSUAL ELECTRIC SWITCH for an automobile carburetor incorporates a complicated housing molded of a phenolic compound. The piston operates in the housing to make and break the circuit.



MOLDED PHENOLIC HORN BUTTONS on new Ford trucks were the source of a production problem because of undercut flanges, which hold the button to the steering post. Parts shown were molded in one piece.



Bakelite Corporation

AUTOMOBILE radio antennas are insulated with two thermoplastics. To assure resistance against weathering and abrasive road materials, antenna lead-in wires are insulated with extruded polyethylene, and the whole wiring unit is encased in a vinyl plastic jacketing. Resistance of these materials to oils and solvents is excellent.

REDUCTION of static interference, increased safety from static hazards, and reduction of maintenance and installation costs are improvements in airplane antenna systems attributed to polyethylene. Tension units, tee splices and strain insulators are now completely insulated with polyethylene, resisting a 200-kilovolt stress over a —50 to 130 F temperature range.

Du Pont Company

UCT ENGINEERING, April 1947 issue).

An interesting method of combatting corrosion in trucks and busses is being used by the GMC Truck and Coach Division, General Motors Corporation. In order to protect clutch, brake and other control rods on the underside of these large vehicles from corrosion and roadbed abrasion, special rods coated with cellulose acetate butyrate are being supplied by Samuel Moore and Company, Mantua, Ohio. The actual extrusion is being done by Carter Products Corporation, Cleveland, Ohio. Extruded of a yellow formulation, the thickness of the coating is 0.015 in.; tolerances are plus 0.000 in. and minus 0.008 in. Use of this seamless coating has greatly increased length of life of the rods.

A new concept of engine vibration control has been incorporated in the 1948 Buick. These GR-S synthetic rubber mountings control engine vibrations as well as chassis vibrations caused by road conditions.

In dealing with engine mountings designers usually stopped with a solution to the frequency aspect of the problem and made little effort to introduce damping. The Buick engine mounting consists of a three-point suspension with two mounts at the front, one on each side, and a rear mount—consisting of two separate parts—located at the torque tube ball joint at the end of the transmission.

Comprehensive tests on various materials demonstrated that GR-S rubber has inherent internal frictional characteristics — high hysteresis value — that gives it unique damping properties. The damping quality of a GR-S mount is equal in performance to natural rubber mounts used with special mechanical dampers.

Electrical Parts

An automobile carburetor, developed by the Eclipse Machine Division of Bendix Aviation Corporation, employs an unusual electric switch, molded by Plastic Research Products Co., Urbana, Ohio, from a phenolic formulation supplied by Durez Plastics and Chemicals, Inc. The problem was to make a complicated housing in which a piston operates to make and break the circuit; metal contacts on the inside of the housing had to be completely free of molding flash with the brass surface of each contact exactly flush with the plastic inner cylinder wall of the housing. A further complication was the necessity of holding the brass inserts, which form the interior contact point, in exact relative position without movement during the molding process. The problem was solved by molding both piston and housing at the same time, eight of each to a cluster, thus cutting down costs.

By means of skillful molding, the molded phenolic horn buttons form functional parts of the new Ford trucks. As shown in the accompanying illustration, the button has three undercut flanges, or "fingers" which hold it on the steering post. It was the operation of undercutting the flanges that previously caused trouble, considerably increasing the unit cost of the piece. As made by Plastic Research Products Company, the button was molded in a single operation with the undercuts molded in. Since the threads are molded in, the piece is manually removed from the die by a simple reverse turn. Another reason for choosing this plastic is that the part is used with electrical contacts.

The problem of properly protecting and insulating automobile and aircraft radio antennas is being solved through the use of extruded polyethylene. Automobile radio antennas, in addition to withstanding sever weathering, must resist abrasive action of road materials thrown up by the wheels. To assure long-lasting antennas, Ward Products Corporation is insulating antenna lead-in wire with polyethylene, and encasing the whole wiring unit in a vinyl plastic jacketing. These plastic materials possess excellent electrical insulation characteristics, resist water, oil, grease, gasoline, chemicals, abrasion, and are non-flammable. Because of the extremely low power factor of polyethylene at radio frequencies, thin diameter insluation is possible, and a smaller lead can be used.

Polyethylene insulation is also contributing to the improvement of a new airplane antenna system. As shown in the accompanying illustration, tension units, tee splices and strain insulators are now completely insulated with polyethylene, which will resist a 200 kilowatt stress over a temperature range of minus 50 F to 130 F. Made of formulation supplied by DuPont, the insulation is molded by Trimold, Inc., of Kenmore, N. Y., for Frederic Flader, Inc., of North Tonawanda, N. Y., manufacturers of the new antenna system. Wiring in the antenna system is also insulated with polyethylene which is extruded directly on the solid-copper-weld, 0.051 in. diameter wire. Use of polyethylene insulation on the various antenna system parts eliminates the expensive, painstaking taping formerly required to insure minimum radio interference; also polyethylene resists electrostatic discharge.

. . Textile Machinery

Toughness and Chemical Resistance Are Two Key Properties

Bobbins

BOBBINS on textile braiding machines have been the source of more material substitution than perhaps any other textile machine part. This is caused by the exceptional stress and abrasion taken by such parts. As can be seen in the accompanying illustrations of two such parts, one end of the bobbin has teeth which engage metal pawls, holding the thread tight, and cutting down back lash—this is one source of shock and wear. A different type of strain is encountered when the material being wound on the bobbin twists more tightly as the tension is increased; an especially high constrictive force is caused when nylon is being processed. Chemical resistance of the part is tested when the bobbin is cleaned in a caustic solution.

The Narrow Fabric Company of Reading, Pa. uses these bobbins on a braiding machine that makes such products as shoe laces and fishing lines. Formerly compression molded of a phenolic compound, impact strength of the bobbins was too low—teeth chipped and there was breakage when the bobbins were shipped back to the textile "thrower". The problem was solved by injection molding the bobbins of ethyl cellulose. Molded by Atlantic Plastics of Flushing, N. Y., the bobbins made of ethyl cellulose exhibit high impact strength and are otherwise satisfactory.

Justifying the suggestion made by the Hercules Powder Company for the use of ethyl cellulose in this application, another manufacturer is injection molding a similar line of textile bobbins from this extremely tough cellulosic plastic. The Dillon-Beck Company of Hillside, N. J., has announced a line of proprietary plastic bobbins designed for use on No. 1 braiding machines.

Thermosetting plastics, including both molded and cast resins, and other synthetics have formerly been tried in similar applications, as textile machine designers sought a more durable and longer lasting material than the conventional hardwoods used to manufacture the bulk of the industry's requirements. None of these, however, could provide the toughness and resistance to impact that was needed. The exceptional toughness of the ethyl cellulose is indicated by the fact that it can usually resist the tremendous compression of tightly wound nylon yarn, while the other materials required an inner support of metal to prevent crushing.

Resistance to wear of the ratchet head which is an integral part of the piece is another feature.

Rayon Spinning Units

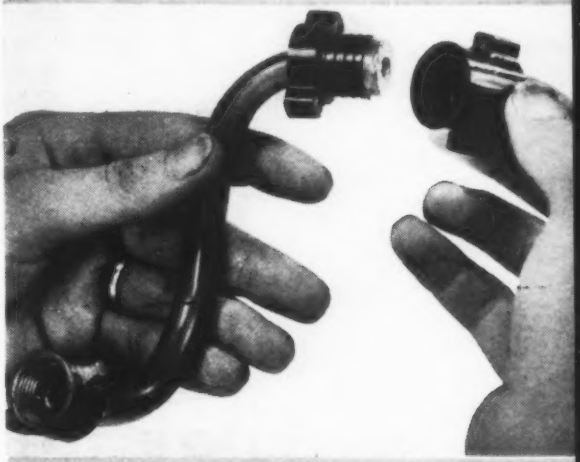
The manufacture of rayon involves the "spraying" of raw stock through a nozzle into a concentrated acid bath, to form a filament. Action of the acid externally and the plastic internally constitutes an important problem in the choice of materials for the tube and nozzle elements which carry the plastic under the bath.

Glass tube elements with lead fittings have been used in the past, but involved a serious breakage problem, as the spinner heads are handled frequently for cleaning, and are swiveled in or out of the bath according to production requirements. Stainless steel has been tried, and found satisfactory in relation to the plastic stock, but not sufficiently resistant to the highly corrosive acids used.

The special products division of The Parker Appliance Company, Cleveland, proposed a solution in the form of an assembly composed of specially molded vinylidene chloride (saran), a thermoplastic, which has been widely accepted as standard. A simple gooseneck is made of saran extruded tube, and molded saran fittings, which are assembled on the shaped tube and a tube shoulder is cold formed on a mandrel. Where larger units are used, stainless steel inserts are used inside the tubes for strength.

Of special interest is the thread form designed by Parker to make saran molded fittings practical, avoiding cold flow tendencies which would destroy the seal if a normal V-thread were used. The Parker thread is almost square, but with a slight reverse angle on the sides. The effect is a dovetail clinching which holds indefinitely.

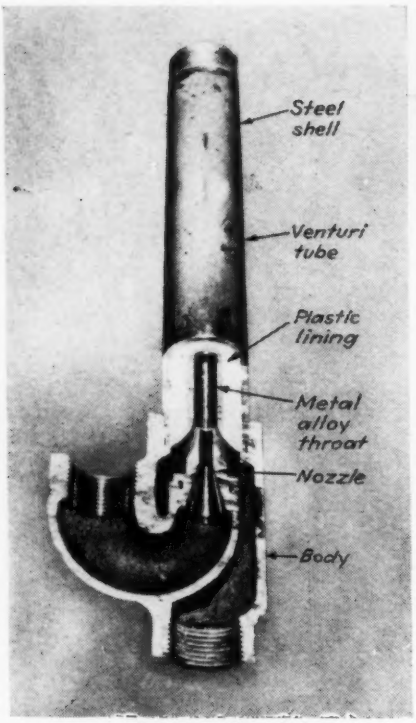
TEXTILE MACHINE BOBBINS, injection molded of ethyl cellulose, must withstand impact and abrasion of engaging pawls, as well as constriction of tightly-wound yarn.



RAYON GOOSENECK shown made of saran extruded tubing and saran molded fittings, combine strength and resistance to corrosion. Dovetail thread forms on the saran fittings solve the cold-flow problem. Fitting at lower left is of the former lead type used with glass tubes.

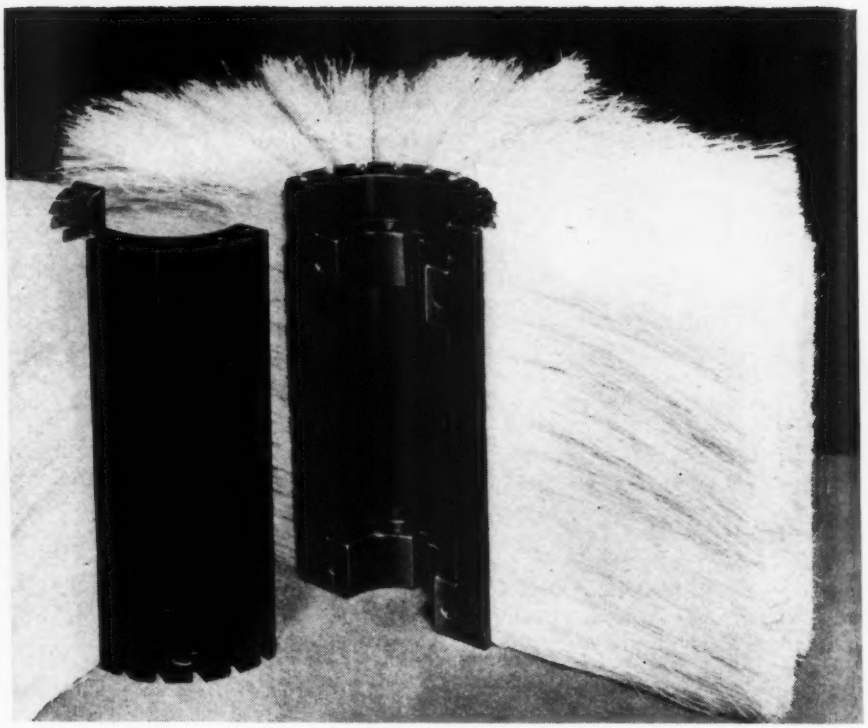
FLYER BLOCKS, textile spinning-machine parts that keep yarn under control during twisting, are injection molded of nylon. The nylon flyer blocks need no lubrication even when whirled at speeds up to 15,000 rpm. They are made in 3 sizes, from 1¼ to 1¾ in. long, and in two colors, black and natural.

Du Pont Company



Durez Plastics and Chemicals, Inc.

VENTURI throat of an hydraulic jet assembly of a water pumping system is cast phenolic, combined with a metal tube.



WASHERS for automobiles and railroad cars are made up of brushes that are molded of a phenolic plastic. Replacing wood, the phenolic brushes are lighter and less expensive than metallic units. They have high impact strength and resistance to alkalis.

. . . Hydraulic Components *Plastics are Chosen*

Water Pump Venturi

AFTER DESIGNING a water pump system superior to any previous model, engineers of the Johnston Pump Co., York, Pa., found themselves confronted with the problem of producing the venturi throat for the hydraulic jet assembly with which the pumping system is equipped. Although a special metal alloy had been found satisfactory for the jet nozzles and the interior of the venturi throats, its cost was found to be out of line because of the shape required too much machining time. Further, it was found that each nozzle had to be matched and carefully aligned to each throat. Variations as slight as 0.005 in. in bores and alignment affected the efficiency of the unit.

The answer was found in a phenolic casting resin (Durez), used in combination with a simple metal tube for the venturi throat. Not only were costs reduced, but the entire assembly was lighter in weight, cutting down handling and shipping charges. Material costs were also lowered.

To produce the venturi throat, the inside of the metal pipe sleeve is coated to prevent attack by the acid accelerator in the casting resin. A precision-machined mandrel, designed in three sections, gives the desired form to the resin. With the metal tube in place on the mandrel, the assembly is placed within the pipe sleeve and the liquid phenolic casting resin poured in. When the resin hardens and cures, the sleeve, cast resin and tube become a homogeneous unit. The normal shrinkage of 0.002 in. per in. is taken into consideration in the design of the mandrel around which the resin is formed. To further hold the three elements together, a small groove is machined at one point on the inside of the pipe sleeve.

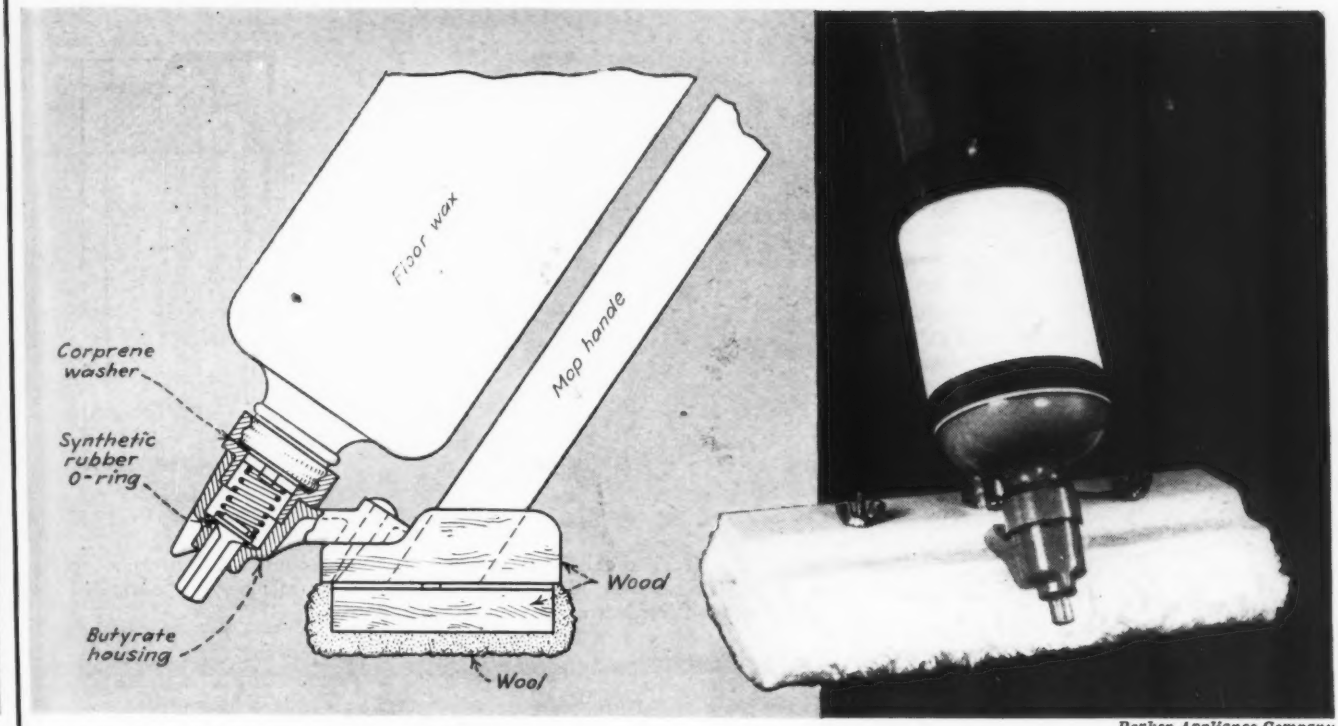
Most important properties of the casting resin for this application are resistance to wear and corrosion. The smoothness and gloss of the wearing surface of the phenolic resin are determined by the finish of the mandrel.

The venturi throat is the point of greatest wear in jet assemblies. They are used in water pumping systems, serving mainly in rural areas where a municipal water supply is not available.

Car Washer

Another application involving resistance of a phenolic plastic to running water is a new car washer molded by the plastics division of the General American Transportation Corporation, Chicago, Ill., of a phenolic plastic supplied by Durez. Manufactured by the Whitin,g Corporation, Harvey, Ill., for the Fuller Brush Co., the washer consists of a series of water sprays and revolving brushes mounted vertically on shafts. Busses and railroad cars driven between two sets of these shafts, are thus thoroughly washed and cleaned. Wooden cores with bristles fastened permanently in place were originally used. However the wood changed dimension and split when exposed to water. Stainless steel, aluminum and other metals were considered but were found to be too high priced and too heavy for the application. Ordinary steel would corrode because of the strong washing solution.

Designed of phenolic plastic, the molded parts are 50 to 60 percent lighter than aluminum and costs less than 20 percent as much. No machin-



Parker Appliance Company

SELF DISPENSING FLOOR WAXER depends on a plastic valve unit for efficient operation. When the waxer is tilted, a small amount of war is deposited on the floor, by means of a spring-loaded plunger. The principal valve parts are molded of cellulose acetate butyrate. The "Corprene" washer, a cork-neoprene compound, seals the screwed-in bottle.

for Dimensional Stability When in Contact With Water and Other Liquids

ing is necessary, since the parts are molded to extremely close dimensional tolerances, permitting complete interchangeability. Additional advantages of the phenolic plastic are its resistance to mild alkalis and high impact strength.

As shown in the illustration, the core is molded in two halves and holds 20 specially developed brush strips. Brass inserts are molded in and brass cap screws lock the core around a $2\frac{1}{4}$ in. double-keyed shaft.

Plastic Valve Unit

An economical all-plastic bottle holder and valve unit designed and manufactured by the Parker Appliance Company, Cleveland, is the key element of a new labor-saving device. When the Sherwin-Williams floor-waxer is tilted, a plunger is depressed to deposit on the floor just enough wax to efficiently polish a small floor area. Operation depends on the valve unit.

The principal valve parts are of molded cellulose acetate butyrate, of sufficient strength to support the weight of a full bottle. A spring-loaded plunger valves the wax for dispensing.

An O-ring, molded by Parker of a synthetic rubber compound of its own formulation, gives a perfect seal with less than 2 lb. spring pressure.

The design is significant in that it points the way to many other plastic valve applications where a good seal can be obtained economically.

Perhaps the most interesting part of the valve unit is the washer that seals the screwed-in bottle. Made of a cork-neoprene combination, this material possesses the compressible characteristics of both cork and elastomeric materials, plus the imperveability and resistance to deterioration that is characteristic of neoprene.

In these cork-neoprene compositions, the compressibility characteristics can be varied by changing the proportions of neoprene and cork in the mixture. A measure of the compressibility of mixtures of neoprene and cork can be determined from the load deflection characteristics of an unconfined sample as compared with a sample compressed within a confined space. Gasket compositions containing increasing amounts of cork are softer and deflect more under a given load.

Neoprene—cork compositions are suited to applications where the sealing pressure on a gasket is variable. Localized high sealing pressure on these gaskets merely produces greater compression of the composition at that point without distortion of the entire gasket. Indicated applications are packings and gaskets that resist oils and hydraulic fluids; transformer that must be impervious to oil, water and gases; and applications that require a seal between glass, porcelain or plastics and metal.

Pump Shaft Seals

Automatic pump shaft seals, manufactured by the Schwitzer-Cummins Co. of Indianapolis, consist of several assembly parts enclosed and protected against rust and corrosion by a rubber sleeve or housing made from nitrile-type rubber manufactured by B. F. Goodrich Chemical Company (Hy-

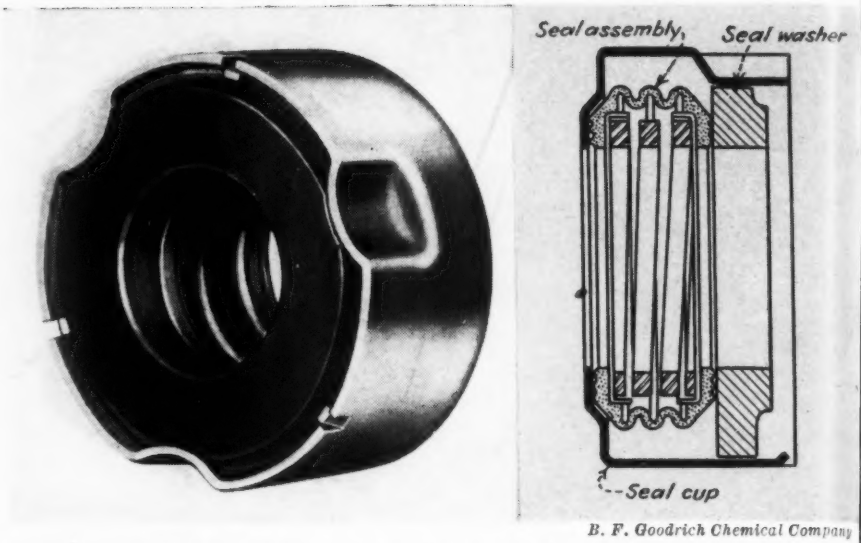
car). These seals are manufactured in a wide variety of types and designs for water pumps in automobiles, trucks, busses, tractors, washing machines and almost any internal combustion engine.

Packing rings, used to prevent water pump leakage in internal combustion engines, by means of glands and packing nuts, became loose after short service, either through wear or by the tendency of the pump shaft to run out. To prevent leakage of the cooling fluid, they continually required tightening, which in time wore the pump shaft. Eventually both packing and pump shaft required replacement. This meant interruption of operation and loss of fluids.

The first automatic pump shaft seal developed by Schwitzer-Cummins consisted of a metal bellows with high-lead bronze sealing disks soldered to the ends. The disks ran against the pumphousing on one end and fastened to the pump impeller on the other end. This design proved to be a satisfactory solution for an automatic pump seal but was too expensive. The metal bellows required a laminated material to prevent it from cracking, and soldering sealing disks to bellows was expensive.

The metal bellows was replaced with a protective sleeve made from a special purpose nitrile-type rubber compound, designed according to the following specifications: Tensile strength—1500 psi. minimum; elongation at break—500 percent minimum; Shore durometer hardness—55-65; good compression set and low temperature properties. These requirements were not uncommon for automotive rubber parts, but certain special conditions posed new problems. These included the retention of a high percentage of the original properties, with a maximum spread in volume change of —5 to +10 percent after aging at 200 F for 250 hours in a variety of anti-freeze and other mixtures such as: 50 percent ethylene glycol and water; 50-50 mixture of alcohol and water; distilled and tap water with and without emulsified oil type rust inhibitors; kerosene; and SAE No. 20 oil.

Operation of the nitrile rubber sleeve proved so successful in preliminary tests that it was incorporated into the design of a new, improved seal which included such additional features as a carbon alloy sealing disk, bonded integrally to the rubber sleeve, thus eliminating the sealing disk as a separate piece; and a sealing flange formed to provide extreme flexibility.



B. F. Goodrich Chemical Company

AUTOMATIC SHAFT SEAL is designed as a one-piece unit. Compression spring, carbon sealing disk and the nitrile-type synthetic rubber member are assembled and completely enclosed inside a non-corrosive metal case.

Steam Vaporizer Housing

THIS VAPORIZER makes use of two phenolic compositions. Entire outer body shell is molded of a "general purpose" phenolic and the steam chamber cover is molded of a high impact-heat resistant phenolic. Functional properties of these materials are low water absorption and the ability to resist continuous heat up to 225 F. Plastics were chosen for economy of production, and the lustrous finish obtainable without additional operations. The unit was designed by Sundberg-Ferar, Detroit, for the DeVilbiss Company.

Reprints of this section are available at 25 cents each, special price for quantities.
Address publisher—PRODUCT ENGINEERING, 330 West 42nd Street, New York 18, N. Y.

Copyright 1948 by McGraw-Hill Publishing Co., Inc. All rights reserved.

Adopt the Metric System

From "British, American and Metric" by Curtis L. Bates, Aeronautics Vol. 18, No. 2, 1948.

AT ONE PERIOD IN THE HISTORY of the world the architects of large structures so prided themselves on their originality that they chose new and previously unused units of measurement for each new undertaking. Such a procedure would hardly fit in our modern world and we have developed now to the point where the entire industrial effort of the world is carried on with only three dimensional systems. Common sense and international necessity will one day demand that there be but one.

The three systems referred to are the Metric System, the British System, and the American System. Dividing the British and American Systems is done advisedly. There are enough variations between units in the two countries to make it impractical to consider them a single system. A comparison of some English and American units appear in the table. There is, of course, considerable question as to whether these can be considered systems at all. We speak of twelve inches per foot, three feet per yard, 5,280 feet per statute mile, 6,080 feet per nautical mile, sixteen ounces per pound (troy). An avoirdupois ounce is 437½ grains; a troy ounce is 480 grains; a fluid ounce is one sixteenth of a pint. Where is there any system?

It has been said that the basic units of measurement are relatively unimportant in themselves. Almost any unit of length could be used, provided a proper system of units was developed around it. As far as basic units are concerned, the yard would probably have been as satisfactory as the meter, had a proper system of units, a decimal system, been built about it. Probably the whole argument of metric units versus English and American units comes down to this one point: The metric system is a logical system; the English and American units have no system.

Let us examine the status of the metric system.

All the civilized countries in the world except Great Britain and the United States, together with associated countries, now use metric units for all their common measurements. Seven countries, including China, Russia and Japan, have adopted it since 1920. In England and the United States the metric system has been legalized for use where desired and such use is considerably more prevalent than is generally realized. Further, the metric system is gaining in use year by year as additional groups, sometimes whole industries, find it expedient to adopt the standard.

Present uses of metric units serve to illustrate the point. In the United States, the Coast and Geodetic Survey uses metric units for base measurements. The United States Mint uses metric weights for coinage. The whole chemical industry is geared to the metric system. Electrical measures are based on metric units by Act of Congress. The American Medical Association now uses metric units exclusively in its publications. Precious stones are weighed by the metric carat. The picture film industry is partially on the metric standard and even the automobile manufacturers have seen fit to use metric threads for sparkplugs.

It is most significant that a great proportion of our scientific thinking and calculating is done in metric units. Our scientists simply could not be bothered with the wheres and whys of an illogical system and long ago adopted the metric system as a matter of course. To a large extent it is the practical application of scientific work that is spreading the use of metric units.

In the international exchange of research data it is necessary to either deal in the same set of units at both ends of the exchange or to translate units at the same time as the translation of the text takes place. The latter procedure is costly and conducive to error. Many English speaking research groups have

Comparison of British and American Units of Measurement

Unit	Definition		Remarks
	English	American	
Yard	0.914399 meter	0.914402 meter	Apparently of double origin (1) the double cubit and (2) the length of an Anglo-Saxon girdle.
Foot	1/3 Imperial yd	1/3 U. S. yd	Originally length of human foot with out further specification.
Inch	1/12 ft	1/12 ft	Originally breadth of a man's thumb. Romans defined it as 1/12 foot, introduced it into Britain during Roman occupation. One inch = 2.54 cm has been adopted by American Standards Association for industrial purposes. This makes one yard equal to 0.9144 meter.
Avoirdupois pound	0.45359243 kg	0.45359243 kg	
Avoirdupois ounce	437.5 grains	437.5 grains	
Fluid ounce	1/20 pint	1/16 pint	This ounce is a unit of volume, not of weight.
Ton	2,240 lb	2,000 lb	The "long ton" of 2,240 lb is used in the U. S. for measurement of tin, rubber, brimstone, pyrites, chrome ore, manganese ore, bauxite, and barytes. It is the measure for anthracite coal in the wholesale but not the retail trade. It is also used for some purposes in the iron and steel trade.
Gross ton	100 cu ft (ship volume)	100 cu ft (ship volume)	This is a unit of volume, not of weight.
Gallon	277.42 cu in.	231 cu in.	

found it simpler to learn to think in metric units than to translate them to English units.

In technical work a considerable amount of time—sometimes estimated as high as 5 percent—is lost in the use of units not having a logical system. In dealing with speeds, for example, we now deal with four sets of units; feet per second for aerodynamic and certain other technical work; statute miles per hour for some aeroplane speeds; nautical per hour for others; and kilometers per hour when giving aircraft performance for international use. The confusion resulting from this situation is paid for in cold, hard cash in our everyday engineering work.

The metric system covers only the units of length, capacity, and weight. We still use a variety of scales for measuring temperature: Fahrenheit, Centigrade, and Kelvin scales being in common use. We use a partial sexagesimal system as well as radians for angular measurement. In the matter of time we use a sexagesimal system for portions of hours and minutes and a conglomerate system for times greater than one hour. The sexagesimal time system leads to a non-decimal relation between meters per second and kilometers per hour. The temperature scale problem is simply one of standardization. The difficulties involved in angular measurement and time are partially alleviated by choosing one of the units, the degree, for example, as a base and using decimal parts of this unit for all smaller subdivisions. This practice could be extended without changing our basic system.

It seems certain that the whole field of international relations would be improved to a measurable extent by our adoption of the metric system. If the English speaking countries were to adopt a definite program for converting to the metric system, it would be a small but certain gesture of goodwill —an indication of intent to come to a common understanding with other countries of the world.

Attempting to apply logic to this whole situation we might recapitulate as follows:

1. Most of the countries of the world have standardized on the metric system.
2. Much work in English speaking countries is done in metric units.
3. Computational work is becoming an increasingly large portion of engineering work.
4. Efficient computational work requires a decimalized system of units.
5. Adoption of the metric for all computational work would provide the closest approach to a fully decimalized system presently possible.
6. The use of metric units in English speaking countries is increasing year by year.

The one outstanding conclusion of all this is that we will eventually be using the metric system exclusively. The question becomes: Should we allow this to come about by slow, natural (and perhaps painful) processes, or should definite steps be taken to make the transition occur more quickly and more easily?

The foregoing conclusions lead to the following recommendations as preliminary steps. It is believed that the results of these steps will point the way to greater use of the metric system.

1. It is recommended that all magazines and technical papers use metric units as the basic system, with English and American units as secondary values, as an interim procedure.
2. It is recommended that full discussion of this whole problem be invited from all quarters and particularly in the various technical societies.
3. It is recommended, as a broad overall policy, that encouragement be given to more extensive training in the metric system in the secondary schools.
4. It is recommended that the English speaking nations cooperate fully with the International Bureau of Weights and Measures, expanding the activities of that group if necessary, to study the possible benefits of establishing a decimalized system for angular measure and for time, together with a recommended international temperature scale to be used for all purposes.

D-C Power Sources for Machine Tools

From "Choosing D-C Power Sources for Machine Tools" by L. W. Herchenroeder, Westinghouse Electric Corporation, presented at April 1948 Machine Tool Forum.

SINCE ELECTRIC POWER is almost universally provided in the form of alternating current, conversion equipment is required for direct current operated devices on machine tools.

Three forms of conversion equipment normally used on machine tools are: The metallic rectifier, which may be of the copper oxide or selenium type; the electronic rectifier; and the motor-generator set. Each has certain advantages and occasionally there is confusion as to the proper equipment to use for a given application.

The problem can be simplified somewhat by reducing it to two parts: The first dealing with a general source of d-c power and the second dealing with d-c adjustable speed drives.

Of first concern is a simple source of d-c power at constant voltage. The curves in Fig. 1 give the list price of 230 volt d-c power sources plotted against kilowatt output.

While the cost of the transformer of an electronic rectifier is relatively independent of the voltage output; the cost of the tubes is determined by the current required. For example, if the d-c voltage is halved in an electronic rectifier of a given kw output, tubes of twice the current rating will be required. Thus, for a given kw output, the electronic rectifier becomes more expensive as the output voltage is reduced.

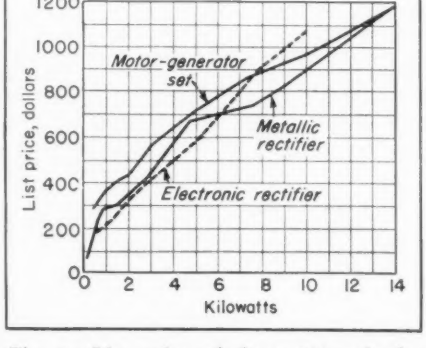


Fig. 1—List price of three 230 volt d-c power sources for different kw outputs.

The motor-generator set is the same price for 125 or 250 volts in the kw ratings herein discussed. Below 125 volts the higher current increases the cost of the commutator and armature resulting in an increased price per kw for the motor-generator set.

The metallic rectifier is quite flexible with respect to output voltage. The transformer can, of course, be arranged to give any reasonable output voltage. By suitable choice of plates or disks and circuits, a wide range of output voltages can be accommodated. Thus the price of the metallic rectifier

is approximately independent of the output voltage.

As can be seen in Table I the installation cost of metallic and electronic rectifiers is approximately the same, as they are both static devices and require no special mounting. Installation cost of the motor-generator set is higher, since it is a rotating device and must be mounted on a firm foundation.

From the standpoint of maintenance the metallic rectifier has a distinct advantage. The aging taps on the transformer may have to be adjusted periodically for several years, but no special maintenance is required.

On the basis of vibration the metallic and electronic rectifiers are equal while the motor-generator is less favorable because of its rotating parts.

Voltage regulation of the motor-generator set is superior; ±3 percent being obtainable by flat compounding at no price increase. Regulation of electronic and metallic rectifiers is about the same, being approximately 10 percent for a self-cooled and about 15 percent for a fan-cooled selenium rectifier. Regulation of copper oxide rectifiers is somewhat higher, being approximately 30 percent for a self-cooled and 15 to 20 percent for a fan-cooled unit. Voltage adjustment is easily accomplished on the motor-generator set by means of a generator field rheostat. Transformer taps must be provided to adjust the voltage of the metallic and electronic rectifiers.

Space requirements are, in general, greater for the motor-generator set. At 250 volts the metallic rectifier requires the least amount of space at 1 kw and below while the electronic rectifier is smallest above 5 kw. At voltages below 250 the metallic rectifier is generally smaller.

Usually the metallic rectifier is the logical choice for a general purpose d-c power supply. It is low in price and requires very little maintenance. The electronic rectifier comes into the picture at 230 volts from ½ to 5 kw where it is the least expensive. Since practically all machine tool applications require less than 15 kw for general purpose d-c power, the motor-generator set is the most expensive of the three power supplies. The motor-generator set finds application where good voltage regulation or ease of adjusting the voltage is required.

Three forms of d-c adjustable speed drives are: The selenium metallic rectifier adjustable voltage drive, the Mototrol electronic adjustable voltage drive, and the motor-generator set adjustable voltage (AV) drive. In simplest form the selenium drive consists of a transformer, a selenium rectifier, an adjustable speed d-c motor, an a-c linestarter, and a motor field rheostat. Speed control is obtained entirely by adjusting the field of the d-c motor. The selenium drive is, therefore, best suited for constant horsepower loads.

The Mototrol electronic drive uses grid controlled thyratrons to supply adjustable voltage d-c to the armature of a d-c motor. Thyratrons may also be used to supply the field of the motor when part of the speed range is to be obtained by motor field control. Standard speed ranges at constant torque by armature voltage control up to 40/1 may be had.

The AV drive is the conventional adjustable voltage d-c drive using a motor generator set to supply adjustable voltage to the armature of a d-c motor. The standard drive provides a speed range up to 8 to 1 by armature voltage control and up 2 to 1 by motor field control for a total speed range of 16 to 1.

These drives are compared in Table II in several ways. The AV drive provides positive slowdown when changing the speed to a lower value in the same direction. This is of importance in cycle types of operation.

To compare the drives on the basis of vibration, the power supply and control should be considered separately from the motor. The selenium and Mototrol power supplies are most favorable from the standpoint of freedom from vibration because they are

Table I—Comparison of Three D-C Power Supplies

Rating 1 is the most favorable

	Metallic Rectifier	Electronic Rectifier	Motor-Generator Set
Price	Lowest Except Cases To the Right	Lowest For 230 volts ½ to 5 kw	Lowest Above 1 kw
Installation Cost	1	1	2
Maintenance Expense	1	2	2
Vibration	1	1	2
Voltage Regulation	2	2	1
Ease of Voltage Adjustment	2	2	1

Table II—Comparison of Three D-C Adjustable Speed Drives

Rating 1 is the most favorable

		Selenium	Mototrol	Adjustable Voltage
Price	Constant Torque	2	3	1
	Constant HP	1	2	1
Speed Range		4 to 1	40 to 1	16 to 1
Speed Regulation		3	1	2
Positive Slowdown		No	No	Yes
Smoothness of Acceleration		3	1	2
Vibration	Power Supply	1	1	2
	Motor	2	3	1
Motor Size	Constant Torque	Increased Frame Size	Increase One Frame Size	Standard
	Constant HP	Standard	Increase One Frame Size	Standard
Rheostat Size		2	1	2
Maintenance		1	2	2
Installation Cost		1	1	2

static devices. The selenium and Mototrol motors have increased vibration because of the pulsating nature of the armature current.

The AV drive has an advantage in the size of the d-c motor for constant torque drives as the standard frame is used. The selenium drive requires a larger motor because the base speed of the motor is at the lower end of the speed range. The Mototrol uses the standard frame size in some cases, however, it is generally necessary to use the next larger frame size because of the added losses caused by the pulsating nature of the armature current. For constant horsepower drives the Mototrol requires an increase of one and sometimes two frame sizes because of the difficulty of commutating the pulsating armature current.

The power supply and control space requirements are not as consistent as the motor size. The selenium drive is the smallest except at 1½ and 2 hp where the AV drive has the advantage. The Mototrol is the largest up to 5 hp where it equals the AV drive. Above 5 hp the AV drive is the largest. The Mototrol and selenium drive are approximately the same size above 7½ hp. The Mototrol has a definite advantage in the size of the speed control rheostat, which is mounted in the pushbutton station. Both the selenium and AV drives require conventional motor or generator field rheostats.

Selection of the best drive for a given application follows no set rule. In some cases the drive may be picked on a single characteristic. In general, a combination of characteristics will determine the drive to be used. For example, if a speed range up to 4 to 1 is required at constant horsepower, a selenium drive is the logical choice because it is low in price and provides a simple, maintenance free drive. Constant torque drives up to 8 to 1 or combinations of constant torque and constant horsepower over speed ranges up to 16 to 1 are best served by the AV drive. Wide speed ranges or close speed regulation are most economically furnished by the Mototrol.

Electric Power and American Industry

Abstracted from "Future Electric Power Needs of American Industry", an address by F. R. Benedict, delivered at the Midwest Power Conference, Chicago, April 7, 1948. Published by Westinghouse Technical Press Service.

INDUSTRIAL CUSTOMERS represent more than half of the power consumption by all customers. In the 20-year period, from 1926 to 1946, number of production workers increased 40 percent, and the kilowatt-hour consumption per industrial worker increased 120 percent from 3,841 to 8,426 kilowatt hours. Of this consumption, about 70 percent is for motors and lighting.

An historical study, which includes both electrical and mechanical power, shows that in 1909 about 2.0 of the 2.9 installed horsepower (about 69 percent of the total) was mechanical, while in 1947 about 6.7 of the 7.2 installed horsepower (about 93 percent of the total) was electric power. Thus a complete reversal took place in a span of about 40 years. To progress, our productivity must increase, and more horsepower must be placed behind the worker. But new uses of electric power must be justified from an economic stand-point.

The words "from an economic standpoint" mean that the new power use must be justified in terms of the cost, quality, and quantity of the manufactured product. The determination of these factors is a complicated engineering problem and requires thorough study and evaluation of every manufacturing detail to determine whether the desired results can be obtained.

With the greatly increased costs of labor, industry is looking with even greater favor upon the application of highly-specialized automatic machinery. According to the Bureau of Labor Statistics, the average earned rate for hourly employees in all manufacturing industries in 1939 was 63 cents an hour. By November, 1947, this rate had soared to $1.26 an hour. This labor cost increase has focussed the spotlight on any methods that can help reduce production costs.

The whole problem of metals joining is being thoroughly studied by industry at the present time. There are many interrelated reasons why the use of resistance welding is expanding and will continue to do so. The basic reason is that this type of welding is a time-saving joining method, particularly adaptable to high production manufacturing.

Until about 1933 there was little resistance welding of any metal except low carbon steel, because welding methods then in use were not well controlled. The use of ferrous and non-ferrous alloys was tremendously accelerated by the war, when it was necessary to develop new methods for welding aluminum, magnesium, and stainless and hardenable steels. These new methods were made possible through the development of equipment for precision control of the welding current.

During the war electric furnace brazing methods were developed to a high state of perfection. Today industry is finding that these methods can be integrated into their manufacturing operations. As these furnaces are usually worked on a continuous basis, they provide uniform loads that are very attractive.

For the brazing of small parts, where the time cycle can be short, induction brazing using high frequencies of 200,000 to 450,000 cps has shown extreme utility. Similar high-frequency equipment is also coming into extensive use in hardening operations in which accurate control of the depth of hardness is required.

Infra-red heating has not yet reached its proper stature in the industrial field even though the infra-red lamp has a low initial selling price and requires only moderate additional equipment for application. Infra-red heat can be used for drying many materials. It is widely used for drying paints and varnishes in all industries and finds about half of its applications in these fields. Other uses are rapidly developing in the textile, paper, and food industries.

Considerable interest is being shown in the continuous annealing of metal products of all types. In the cold rolling or forming of sheet metal products, the reduction of thickness produced by rolling, or otherwise forming, hardens the material. After a certain amount of cold work is done on the material, it must be annealed, and it then continues through its process. In some operations, it is necessary to anneal as often as five times during the process. If this annealing could be done on a continuous basis, considerable advantage could be obtained in speeding up the process, as it would eliminate many handling operations. Induction heating, using frequencies from 60 to 200,000 cycles, is being actively investigated and may find wide use in industrial processes within the next few years.

Resistance furnaces with controlled atmosphere were used in large num-

bers during the war for continuous furnace brazing, annealing, and heat-treating of all types of metal products. The largest user was the aviation industry, although the iron and steel industry was a close second.

Radio frequency heating was also applied during the war to the reflowing of tin on tinplate. Approximately 10,000 kw of RF heating at 200,000 cycles has been reflowing tin since 1943. This type of load is continuous and is usually on a 24-hour basis. If high output tubes in the order of 500 kw can be commercially developed, this type of heating will be attractive in the continuous annealing fields.

At the higher frequencies above two megacycles, two general fields appear to be most attractive. The first is in the heating of dielectric materials using frequencies up to 30 megacycles, the second is in the development of continuous drying processes.

Positioning Control Systems

From "Electrode Control for Arc Furnaces" by C. E. Valentine and E. H. Browning, Westinghouse Electric Corporation, presented at 1948 AIEE General Meeting, Pittsburgh, Pa.

SEVERAL DIFFERENT SYSTEMS are used in arc furnaces to maintain a preset value of power input. Throughout the furnace heat, such systems automatically change the position of electrodes to compensate for movement of the charge and consumption of electrode material. On a recent test, the rotating regulator gave the best overall performance. Basic types of systems are:

CONTACT MAKING AMMETER. The current adjusting rheostat, shown in Fig. 1, presets the value of arc current to be maintained. The coil of the contact-making ammeter is so energized that it makes contact if the current is more or less than the pre-selected value. Depending upon which contact is closed, the electrode motor raises or lowers the electrodes to restore the arc-current to its correct value.

BALANCED BEAM. An improvement over the current-type, this system uses both arc current and arc voltages as controlling references. As shown in Fig. 2 regulating element controls contractors that apply proper polarity to the electrode positioning motor.

ROTATING REGULATOR. The Rototrol system shown in Fig. 3 also responds to electrode current and arc voltage. Static circuits compare the values from the furnace circuit; and a rotating machine supplies variable voltage output of correct polarity and magnitude to the electrode motors. In a recent test of 50 similar heats each, the rotating regulator gave better performance than the balanced beam type. The Rototrol showed somewhat: (1) lower power consumption per ton of steel; (2) quicker heating; (3) smoother operation; (4) less electrode breakage; and (5) less mechanical maintenance.

ELECTRONIC REGULATORS. A few experimental electronic regulators are installed. Generally, the results are satisfactory but more experience is necessary before they can be fairly compared with other types.

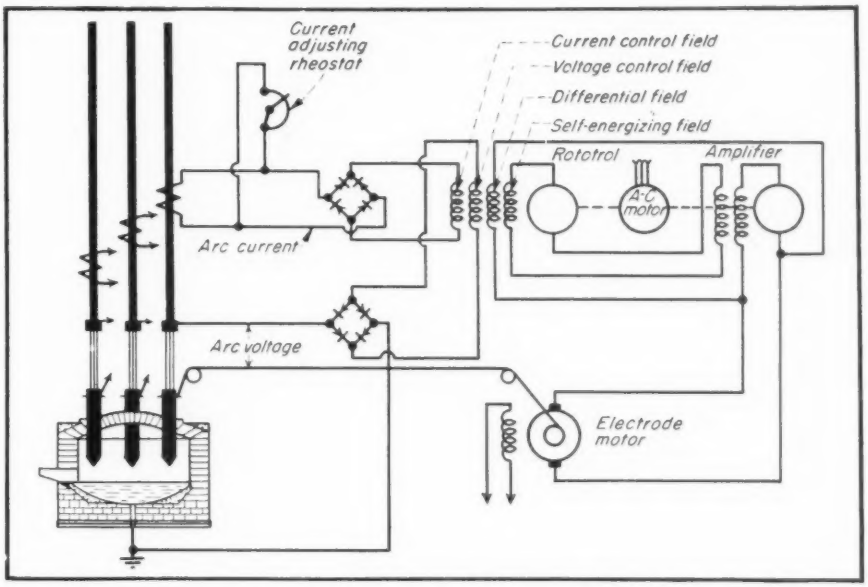


Fig. 3—Schematic circuit diagram of rotating regulator, Rototrol system.

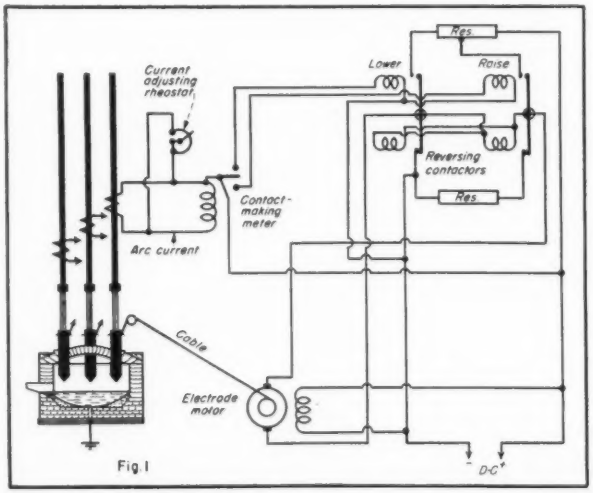


Fig. 1—Contact-making ammeter operates on arc-current.

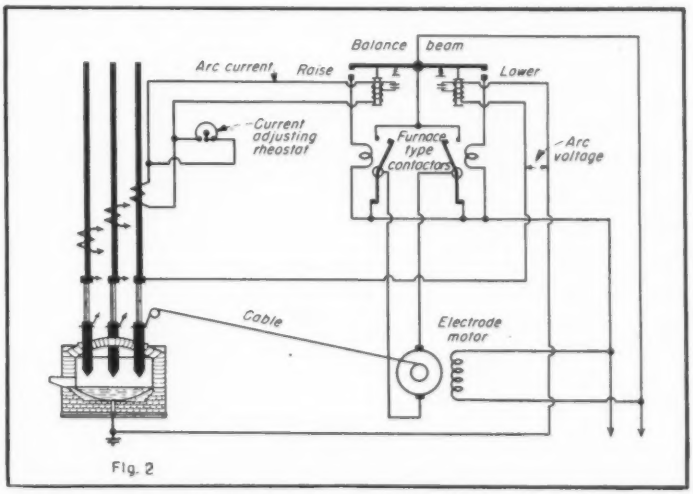
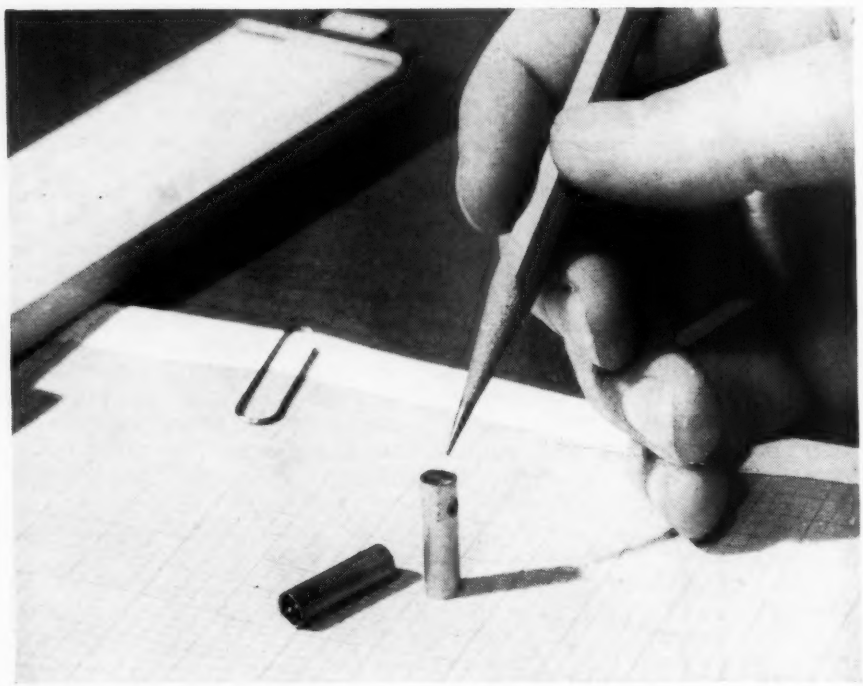


Fig. 2—Balanced-beam operates on both arc-current and voltage



AMPLIFIER OR OSCILLATOR, this small unit can be used to replace vacuum tubes in many circuits. Units have produced amplification as high as one hundred to one.

Semi-Conductor Replaces Vacuum Tubes

A SIMPLE DEVICE, smaller in diameter than a pencil and capable of efficiently performing almost all functions of an ordinary vacuum tube, has been recently demonstrated by Bell Telephone Laboratories. Known as the Transistor, the device works on a new principle discovered by the Laboratories during fundamental research into electrical properties of solids.

The apparatus is housed in a cylinder less than 1 in. long. It will serve as an amplifier or an oscillator—yet it bears little resemblance to the vacuum tube now used to do these basic jobs. It has no vacuum, no glass envelope, no grid, no plate, no cathode and therefore no warm-up delay.

Two hair-thin wires touching a pinhead of a solid semi-conductive material soldered to a metal base, are the principal parts.

Since the device is still in the experimental stage, no data on cost are available. Its essential simplicity, however, indicates the possibility of widespread use, with resultant mass production economies. An expensive item is the rare germanium now used as the semi conductor. When fully developed, the Transistor is also expected to find new applications in electronics where vacuum tubes have not proved suitable.

Tests have shown that the Transistor will amplify at least 100 times (20 decibels). Some test models have been operated as amplifiers at frequencies up to ten million cycles per second. Because of the simple structure, stability and long life are expected.

The demonstration emphasized some of the many uses the Transistor may have in telephone communication, as well as its ready adaptability to the electronic techniques of radio, television and public address systems.

In another, a radio broadcast was picked up by a set constructed entirely without vacuum tubes; using instead several of the tiny Transistors to provide amplification.

A Transistor was also used to generate a standard frequency tone, thus demonstrating its role as an oscillator. Because of its lack of a heated cathode delay and other differences, the Transistor can also perform some new functions.

In the Transistor, two point contacts of the "cat's whisker" or detector type, familiar to radio amateurs, are made to the semi-conductor only two thousandths of an inch apart. Input power delivered to one of these contacts is amplified at least 100-fold and transmitted to the other terminal where it is delivered to an output circuit. The Transistor is energized by voltage supplies, such as batteries, which apply bias voltages to the two points. Power consumed in the Transistor is less than a tenth that used by an ordinary flashlight bulb, according to the developers.

The amplification process can be understood in terms of the discovery that the input point is surrounded by an "area of interaction." Within this area the electronic structure of the semi-conductor is modified by the input current. If the output point is placed in this area, the output current can be controlled by the input current. This control of output current by input current is the basic mechanism of amplification.

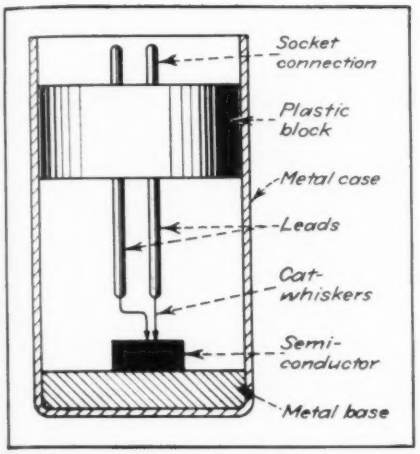
Semi-conductors have for many years been regarded as an ideal field for research at Bell Telephone Laboratories. These materials, whose electrical properties are intermediate between those of metals and insulators, offered particular promise of useful electrical applications, since their ability to carry electrical current can be changed over wide ranges in various ways.

These materials, like any having the ability to conduct electrical currents, rely for conductivity on the presence of current-carrying electrons. In metals, which are good conductors, there is a ratio of approximately one current-carrying electron to every atom. In insulators, there are practically no such electrons and therefore little conductivity.

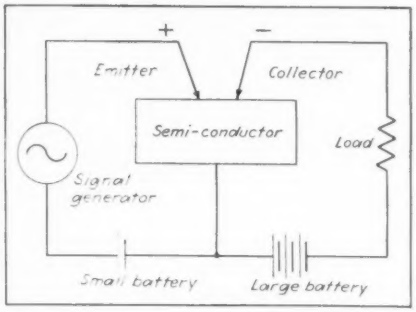
In semi-conductors, such as silicon and germanium, some metallic oxides and other compounds, there may be as few as one current-carrying electron for every million atoms. However, this number of carriers can be varied 1,000-fold or more by changing the electronic structure of the materials. Hence the current flowing through the semi-conductor can be controlled.

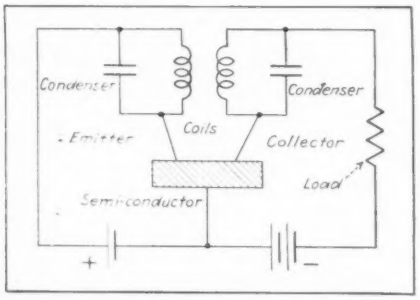
Prior to invention of the Transistor, varying conductivity in semi-conductors was employed in rectifiers, such as the copper oxide and selenium rectifiers, and the silicon detector.

In critically examining the implications of the prevailing theory of electrical conduction in semi-conductors, Bell Laboratories scientists predicted that it should be possible to



TRANSISTORS are simple in construction but replace vacuum tubes in radio and other communication circuits.





SIMPLIFIED CIRCUITS for using Transistor as amplifier (above) and oscillator

control the meager supply of electrons inside a semi-conductor by influencing them with an electric field imposed from the outside without actually contacting the material. Realizing the practical implications of such a possibility they devised some experiments to test this hypothesis but were unable to secure positive results. The electrons seemed to get trapped in the surface of the material and did not behave just as anticipated.

This part of the problem was tackled on a theoretical basis. A theory was developed of what happened at the surface which was able to explain satisfactorily many of the observed facts and which led to further experiments. In the course of these experiments the Transistor was invented.

Transistor action depends upon the fact that electrons in a semi-conductor can carry current in two distinctly different ways. This is because most of the electrons in a semi-conductive solid do not contribute to carrying the current. Instead they are held in fixed positions and act as a rigid cement to bind together the atoms. Only if one of these electrons gets out of place, or if another electron is introduced in one of a number of ways, can current be carried. If, on the other hand, one of the electrons normally present in the cement is removed, then the "hole" left behind it can move like a bubble in a liquid and thus carry current.

In a Transistor made of semi-conductor which normally conducts only by the extra electron process, current flows easily into the input point, which is at a low positive voltage, and out of the output point, which is at a higher negative voltage. The area of interaction is produced by "holes" introduced by the input current and collected by the output point.

Although the device is still in the laboratory stage, Bell scientists and engineers expect it may have far-reaching significance in electronics and electrical communication. Future experiments will not only definitely show limits of present Transistors, but may lead to Transistors with numerous catwhiskers that will be capable of replacing more than one vacuum tube.

Colleges Offer Advanced Courses to Industry

SEVERAL COLLEGES and universities have started tuition courses to help keep members of industry informed on latest techniques used in particular industries and in methods applicable to many industries. Courses will be under leadership of noted educators and industry personnel. Following are some of the courses available.

PLASTICS APPLICATIONS

New York University is planning a course in plastics to be offered in cooperation with the Society of the Plastics Industry. This course, provided it receives support from industry, will be given on fifteen Wednesday evenings at 6:15 to 8:00 pm from October 6, 1948 through January 26, 1949. Tuition fee is set at $35. Probable location for lectures is the Concert Hall of the Barbizon-Plaza Hotel, 58th St., and Avenue of the Americas, New York, N. Y.

Permanent co-chairman of the course will be Dr. Marie Bentivoglio, Chairman of the SPI Educational Committee, and Mr. Charles A. Breskin, Editor and Publisher of *Modern Plastics*.

Chief aim of the proposed course is to correlate information about 25 major industries that use plastics. Each evening leaders from these end-product industries, as well as from the plastics field, will address the class. Ample opportunity will be provided for questions and discussions.

Additional information on the course, "Plastics—Present and Potential Uses and Application in Industry", can be obtained from New York University, Division of General Education, 100 Washington Square East, New York 3, N. Y.

QUALITY CONTROL

An intensive ten day course in Quality Control by Statistical Methods is announced by Dean F. M. Dawson of the College of Engineering and Chairman of the Committee on Quality Control, and by Dean Earl J. McGrath of the College of Liberal Arts at the State University of Iowa. The course will be given October 5-15, 1948, inclusive, at Iowa City, Iowa.

INDUSTRIAL EXPERIMENTATION

A five-day training conference in Industrial Experimentation will be offered by the Engineering School of Columbia University, New York, September 14-18, 1948. The course is intended to provide both formal and practical insight into fundamentally effective techniques for persons with a background of experience and at least one course in statistics, quality control, or the equivalent.

The subject matter of each day will be treated as a unit, the morning periods given over to presentation of formal principles and problems, while the afternoons will be conducted as clinic sessions, with specialists from industry as speakers. The topics to be considered include the nature of problems in industrial experimentation, the role of control charts, correlation, analysis of variance and their interrelation in the design of experiment; assumptions underlying analysis of variance, one-way and two-way classifications; Latin squares, factorial designs, sequential methods. There will also be a special session on computing machines at the Watson Scientific Computing Laboratories. Three full-time instructors from Columbia University and five industry specialists will conduct the sessions.

Arrangements have been made for dining as a group at the Men's Faculty Club. Provision has also been made for inexpensive lodging on campus. The fee for the Conference, including

all books and supplies and all lunches and dinners at the Men's Faculty Club is $100. Further inquiries and requests for brochure and application may be addressed to Professor S. B. Littauer, Department of Industrial Engineering, Columbia University, New York 27, N. Y.

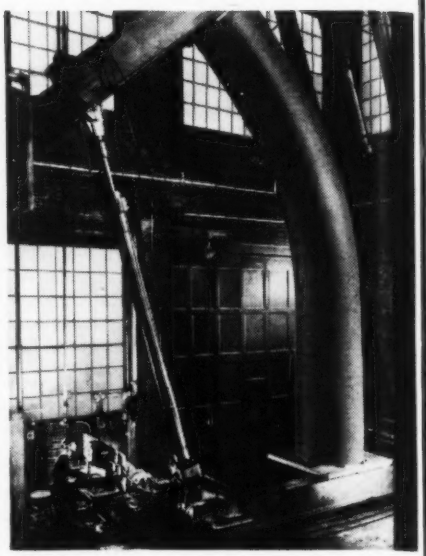
Largest Pipe Bending Machine

SMOOTH BENDING of pipe large enough to garage a limousine has been proven both possible and practical by a new process recently announced by the M. W. Kellogg Company, Jersey City, N. J.

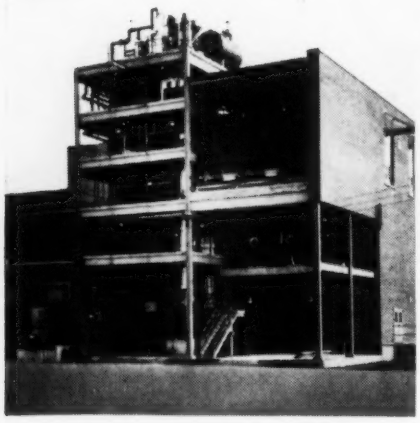
Pipe bends larger than for old limit of 34 in. diameter are being made with the new machine. These bends are not only passing strictest production tests but are of higher quality than bends fabricated by the usual welded segment procedure.

The machine is built to handle pipe diameters of 100 in. The method bends pipe in the hot state (1,450 F) using two hydraulic cylinders. It is adaptable to small and large diameters, to thin and thick-walled pipe, and to short or long radius bends. It is currently being used to form 50-in. pipe bends for the carrier lines of large oil refining units.

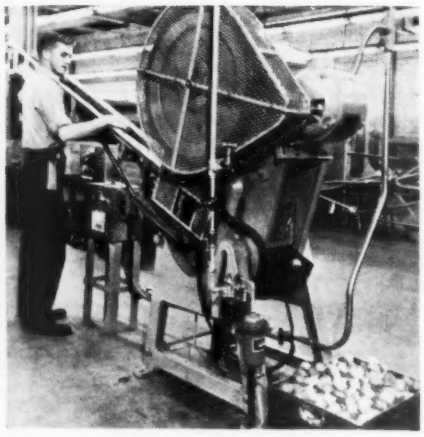
The great value of the new process is said to lie in improved product, in superior performance and reduced maintenance to be gained from uniform pipe contours both inside and out. The smooth even bend markedly reduces erosion and eddy currents caused by sudden changes in direction or sharp-cornered fillets that act as stress raisers. And because the pipe is bent hot and slowly cooled, the stress remains uniform throughout the bend thereby minimizing the effects of stress corrosion. Although development of stress corrosion cracks can be minimized by heat-treatment, it is efficient to make a smooth bend from one piece of large-diameter pipe.



LARGEST one-piece bend ever made, this 50 in. dia. pipe is shaped for use in catalyst carrier lines for refineries. One hydraulic cylinder pulls and one pushes on opposite ends of beam on top of pipe.



NEW PLANT building contains distillation equipment for the manufacture of "Lucite" acrylic resin. Equipment is designed for almost automatic operation.



NEW MACHINES include this hank cutter for nylon brush bristles. Long hanks of filament are cut to proper size for industrial, household and paint brushes.

New Plastics Molding Powder Plant Opens

COMBINING MODERN EQUIPMENT and streamlined processes, the recently completed Washington Works, Parkersburg, W. Va., of the Du Pont Co. is more efficiently turning out plastics molding powders with more exact properties. Full production will be reached this fall.

The plant produces plastics in the form of molding powders of "Lucite", polyethylene and nylon, and monofilaments of nylon. As nearly as possible under conditions peculiar to plastics manufacture, materials are produced in straight line processes that start with movement of chemical raw materials from tank farms and end with finished products, packaged and ready for shipment. Safety devices have been designed into the new machinery and medical services of a doctor and two nurses are available at the plant.

Materials that aid in transforming liquid "Lucite" monomer into a solid are weighed and added to the monomer in new and wholly automatic equipment that avoids possibility of human error or lack of precision.

With the opening of the Washington Works, it became possible for the first time for the Du Pont Plastics Department to start production of its nylon at an earlier stage; beginning with preparation of some chemical ingredients. Having control of earlier processes means that nylon can be "tailor made" for specific plastic applications.

Much of the equipment for the new plant was specifically designed to make other improvements in nylon. Better facilities are available for keeping the powder dry and delivering it to molders in best condition. New machinery for spinning and drawing monofilament to give it greater uniformity, especially in the form of tapered bristles for paint brushes, has been developed. New machines for paper-wrapping bristling materials have been built so that bristles can be handled easily by brush manufacturers.

To make certain that materials shipped from the plant have properties specified, all production is continually checked in quality-control laboratories. Performance of materials under molding conditions is tested in a large injection molding machine. A physical testing laboratory is used to determine strength of molded material, their resistance to high temperatures and other of their physical properties.

The new facilities represent Du Pont's greatest single plastics expansion since it entered the industry in 1915 with a plant at Arlington, N. J.

Washington Notes

Cement Institute Decision Disturbs Industry

Action of many steel companies in abandoning traditional basing point system of quoting prices adds to the growing demand that Congress act to eliminate confusion created by the Supreme Court decision in the Cement Institute case.

Meanwhile, industry is watching the Federal Trade Commission closely and trying to plan for all eventualities. Steel fabricators have said they may be forced out of business if the basing point system is abandoned. One Detroit wheel manufacturer is searching for plant space in Pittsburgh area. This may be a trend that could defeat industry plant dispersal plans being formualted in Washington.

One indication of how hard the FTC will swing the cement decision against delivered pricing in other industries is found in a recent FTC case against a number of producers of white lead and other pigments.

In a brief on a trial examiner's recommended decision, FTC trial lawyers reiterated the idea that delivered pricing is illegal only if commodity is standardized with little quality difference between producers and so heavy that freight charges are an important part of the final cost.

In the lead case, the trial examiner ruled that use of delivered price doesn't result, in this industry, in discrimination against buyers in a single zone. He also ruled that different prices in different zones produced price discrimination.

Commission attorneys saw in this logic a chance for defendants to use a universal delivered price—or one-zone system. If same price in a single zone isn't discriminatory, why not enlarge zone boundaries to include the whole country? It will be some time before the five Commissioners go on record in this case.

Armed Services Procurement Will not cause Shortages

After weeks of slide rule computing, military budgeteers have come up with a set of figures that indicate little impact on domestic economy by military purchases this year. Of the 14.7 billion dollars in obligational authority handed out by Congress, the three services figure they can spend 12 billion during the next 12 months. Remainder will be held over for future payment for goods ordered now. Seventy-five percent of available funds will be used for running expenses; twenty-five for purchases.

Procurement program will require 1,250,000 short tons of carbon and alloy steel—2.1 percent of U. S. production. Airplane program will use about 4.5 percent of aluminum production. Long-range plane building program will require peak 16 percent of total aluminum production by 1951, when 5,200 planes are scheduled.

Army Use of Scientists

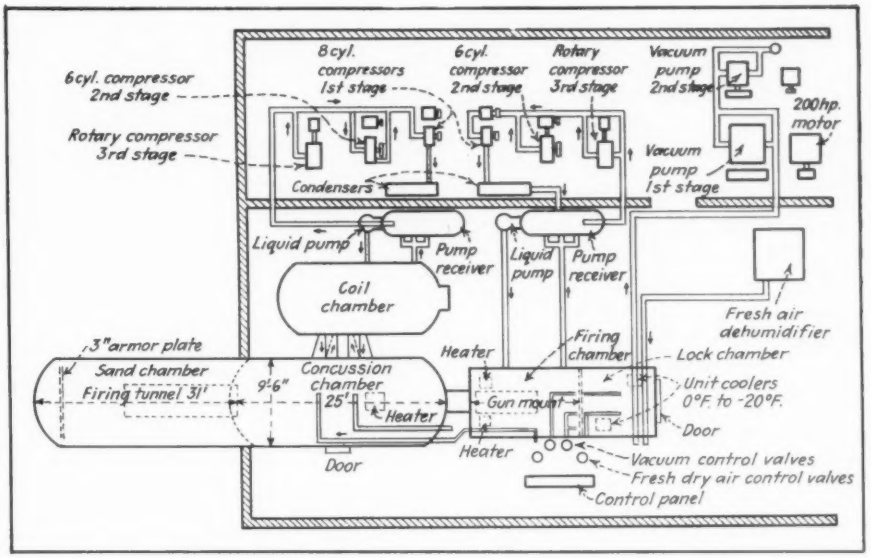
Military manpower planners are about ready to sum up their findings on use of approximately 70,000 scientists by the armed services during the last war. Staff people in the army have many recommendations in mind resulting from these studies.

They would like the Secretary of National Defense to go on record favoring assignments of scientists outside of the military draft. This means the military, or some other government agency, would have authority to tell scientists where to work during wartime. Chances of such a recommendation being made are slight; if made, chances of becoming law are even less.

They would like to have a peacetime catalog of all scientific personnel.

They feel armed services should have copies of university records of all science students.

They would like to analyze scientific



Pressure Chamber Solves Ballistics Problems

COMPLEX BALLISTICS PROBLEMS encountered in computation of ordnance equipment performance at high altitudes are being solved in the world's largest pressurized firing range. The recently activated stratospheric facility (PRODUCT ENGINEERING, July 1948, page 146) at Aberdeen Proving Ground, Md., is now in full operation. Equipment is of capacity to hold conditions equivalent to ten-mile elevation with a load consisting of two persons in electrically heated flying suits, lights, blasts from automatic guns and 308 cfm of fresh dry air. Fresh dry air is admitted to the concussion chamber to decrease concentration of unburned powder gases. Fresh air is admitted to the firing chamber to keep the oxygen content of the air from reaching a hazardous concentration. This concentration is the result of personnel breathing pure oxygen, of which only part is physically used.

Cooling to low temperature is accomplished by two three-stage refrigeration systems using Freon-22 as the refrigerant. Refrigeration equipment can maintain any desired temperature between ambient and —70 F automatically.

The vacuum system is controlled by manual operation of valves at the chambers. Fresh dry air is supplied through Rotometer Valves that measure amount being admitted. Silica gel is used to dry the air.

Pressures equivalent to altitudes up to 50,000 ft are obtained with a two-stage vacuum pump system. Chambers are equipped with electrical heaters that can raise temperature to 160 F. Power is supplied by a unit substation of 750 kva capacity.

needs of the country—military and civilian. These staff members feel that a separate office should be set up within the military establishment to handle all these manpower problems.

Chemical Plant Dispersal

Chemical companies will be first questioned by National Security Resources Board in connection with studies of industrial facilities dispersal.

The 35 companies to be visited will form a cross section of the chemical industry, but each will be a producer of a critical chemical. Companies have dubious distinction of being logical targets for enemy attack.

This survey will serve as a guide and check on NSRB thinking and planning. Survey will try to show: If industry is informed about plane dispersal; what management thinks can and should be done, and what chemical industry is doing about dispersal in connection with expansion plans.

The NSRB plan does not include moving existing plants. Instead, it emphasizes need for dispersal planning before construction of new plants.

If One is Good, Three are Better

The U. S. Department of Agriculture is conducting extensive investigations to find ways of making useful products from farm surplus commodities. The department felt it could better do this work if it controlled an alcohol plant. Knowing that WAA and RFC controlled wartime alcohol plants, agriculture department officials asked Congress for one.

Congress, and the farm bloc, were receptive but felt that if one plant would be good, more would be better. They therefore transferred three plants to the department.

Astonished agriculture officials are now owners of 13.7 million dollars worth of alcohol plant capacity with authority to use or lease plants as they see fit. Alcohol production will undoubtedly continue, but researchers will carry on much pilot-plant work. Cheaper alcohol from grain is predicted after experimentation.

Foreign Reports from McGraw-Hill World News

Czech Builds Road-Type Gas-Turbine Engine

A Czech engineer, George Lakes, now working in the car repair shops at Hameln, in the British Zone of Germany, has become another entrant in the race to design a gas turbine for road vehicles. His engine is built from scrap; his only tool was a 6 in. lathe.

Apparently, Lakes' engine (about 150 hp) combines, as the propulsive force directed into the turbine, a mixture of steam and burnt-fuel gas, at a maximum temperature of 985 F. The exhaust gas mixture is cooled in an air-cooled condenser, which should mean there is no heat-exchanger. Speed of rotation is 13,000 rpm. Calculated potential thermal efficiency is 20 to 30 percent; thermal efficiency of the rough prototype is figured as only 5 percent.

Water is Motive Power For Australian Machines

Five lives have been saved in a Melbourne hospital by a waterdriven standby pulsator which operates the hospital's iron lungs in periods of electricity or motor failures; and a Sydney firm has tooled up to produce five hundred washing machines a week that are driven by tap water.

Both hydraulic units are designed to operate at pressures down to 60 psi, though the main pressure at the tap is usually closer to 100 psi.

The pulsator was developed by the chief engineer of the Austin Hospital, Heidelberg, Melbourne, Mr. Edward Cartwright. The hydraulic unit consists of a cylinder with a reciprocating ram, a control valve for alternatively admitting and discharging water from opposite ends of the cylinder, and a spring-actuated mechanism for automatically reversing the operative position of the control valve. The breathing cycle of the iron lungs is adjusted simply by regulating the tap flow.

The washing machine was developed by a Melbourne engineering firm, O. Granowski Co., and is being produced by R. B. Davies Pty, Ltd., Sydney. Because of its simple construction it sells at half the cost of Australian-built electrical washers.

The motor is designed to be mounted concentrically on the central vertical shaft of the washing machine, and the water is supplied and withdrawn through channels in this shaft. The motor could be described as a semirotary pump worked in reverse. Lubrication is provided by water.

Patent Office for Pakistan

A Patent Office has been set up by this new country under jurisdiction of the Ministry of Commerce, Industry and Works. Patents obtained in India prior to partition on August 15, 1947, will be honored in Pakistan. Any applications filed since then must be made to each country separately.

Seven-Second Soldering Gun

Containing a transformer of special design, a new soldering iron that will heat to working temperature in 7 sec has recently been placed on the market in England. The Burgoyne Engineering Co., Ltd. spent two years developing the transformer and designing the gun.

In this transformer, the main power supply is stepped down to $\frac{1}{3}$ v. The secondary winding leads out through plastic housing and forms holder for the soldering tip, which is heated by induction. The gun is so shaped that when laid on its side, tip is clear of the surface.

Russian Plastics

Minister of the Soviet Chemical Industry, M. Pervukhin, recently announced that as a result of press criticism condemning the low artistic quality and "foreign-copied" designs of consumers goods made from plastics, the ministry had decided to drop from production nine items of a total 290 plastic articles on the output program.

While acknowledging that criticism was justified with respect to need for improving decorative coloring of articles made from plastics and celluloid, Minister Pervukhin said that many of the articles mentioned in the critical "open letter" had already been dropped from production.

To improve the plastics output program, the minister announced that during 1948, 136 new items of plastic ware were to be produced. Majority of the items are to be consumer goods. The Chemical Industry has also been ordered to provide the plastics producers with more stable and diversified dyes, and also to improve the quality of amino-plastics from which mass consumer items are produced.

Formula Reduces Number of Variables Involved In Creep

A FORMULA that is extremely useful in reducing the number of variables involved in the problem of creep has been derived by C. W. MacGregor, Director of the Office of Naval Research Project to discover an explanation of the mechanism of metal creep at elevated temperatures and J. C. Fisher, at Massachusetts Institute of Technology where research is being done.

Application of this formula produces a composite variable, called the velocity-modified temperature, which expresses the interrelationship of testing temperature and strain rate.

Where T_m is the composite variable (velocity-modified temperature): T is the absolute testing temperature; k and ϵ'_o are constants, and ϵ' is the true strain rate, the findings are expressed by the formula:

$$T_m = T\left(1 - k \log_e \frac{\epsilon'}{\epsilon'_o}\right)$$

For a reasonably stable alloy, the stress σ can be expressed as a function of the strain ϵ and T_m the velocity-modified temperature. It has been shown that this relationship holds for slow tension tests, for fast tension tests of impact type and for slow creep tests as far as existing creep data can be applied.

The Office of Naval Research contractors are investigating whether or not the velocity-modified temperature concept can be used in general, and if not, under what conditions it can be used. Constant load creep tests and constant strain rate tests are being conducted at temperatures and strain rates that cover a wide range in small steps. Influence of recrystallization, strain aging, and other metallurgical phenomena will be studied and the velocity-modified temperature expression will be changed, if necessary, to incorporate the new data.

Aluminum wire $\frac{1}{8}$ in. in diameter is being used in the first tests, permitting hundreds of tests to be made economically with assurance that all specimens will be from the same melt, and hence uniform. In later tests more complicated alloys will be used.

A constant strain rate machine, dead-load creep machines, temperature recorders and controllers, and other related equipment have been installed and the initial tests are under way.

Results of this research project will be especially useful in development of gas turbine, jet propulsion and atomic energy units, where high temperatures are essential to high efficiency.

AERODYNAMICISTS can observe shadows made by shock waves of a jet stream on this mirror. Shadow is that of a hand held in position of jet stream.

Ram-Jet Research Aided by Mirrors

SHOCK WAVES, caused by deflection of a jet stream as it strikes an object in its path, can be observed in a new shadowgraph developed by Boeing Airplane Co., Seattle, Wash. From angle of shock, observers can calculate velocity and direction of the stream.

The Boeing shadowgraph is a by-product of a set-up created primarily for Schlieren photography in that the light source is used primarily for the Schlieren system. With mirrors, Schlieren and shadowgraph systems can be operated from one light source. Photographs are made by sending parallel rays of 5,000 candlepower light from a lens across the supersonic stream of the jet. Differences in density of the stream deflect light rays from their normal path, making it possible to photograph them or to throw their shadows upon a ground-glass screen.

Shadowed image of the waves is made possible by a series of mirrors. The first $2\frac{3}{4}$ x $1\frac{3}{4}$ in., is placed beneath a small 1,000 w light bulb reflecting its powerful rays to a second mirror mounted at a 45 deg angle directly under the jet stream. From the second surface, light travels up through the stream. There it creates shadows of shock waves and throws them upon a sandblasted Plexiglas screen above the stream. A third mirror reflects shadow image from screen to a fourth reflector, 5 ft off the floor, where it can be observed from the window of a nearby observation cell.

Boeing research into supersonic flight includes study of shock waves on air flow over aerodynamic shapes.

MEETINGS

September 5-11
International Congress of Applied Mechanics — Imperial College of Science and Technology, South Kensington, London, S. W. 7, England.

September 7-9
SOCIETY OF AUTOMOTIVE ENGINEERS—Tractor and Diesel Engine Division Meeting, Hotel Schroeder, Milwaukee, Wis.

September 13-15
Pennsylvania State College—Conference on Research Administration, State College, Pa.

September 13-17
INSTRUMENT SOCIETY OF AMERICA—National Instrument Conference and Exhibit, Convention Hall, Phila., Pa.

September 20-21
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Aviation Division Meeting, Dayton, Ohio.

September 20-24
ILLUMINATING ENGINEERING SOCIETY—Annual Meeting, Hotel Statler, Boston, Mass.

September 27-October 1
SOCIETY OF THE PLASTICS INDUSTRY—National Plastics Exposition, Grand Central Palace, New York, N. Y.

September 28-October 1
ASSOCIATION OF IRON AND STEEL ENGINEERS—Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio.

September 30-October 3
THE INSTITUTE OF RADIO ENGINEERS—West Coast Convention in conjunction with West Coast Electronic Manufactures Convention, Biltmore Hotel, Los Angeles, Cal.

October 5-7
New England Materials Handling Exposition—Mechanics Hall, Boston.

October 12-16
AMERICAN CHEMICAL SOCIETY—National Chemical Exposition and National Industrial Chemical Conference, The Coliseum, Chicago, Ill.

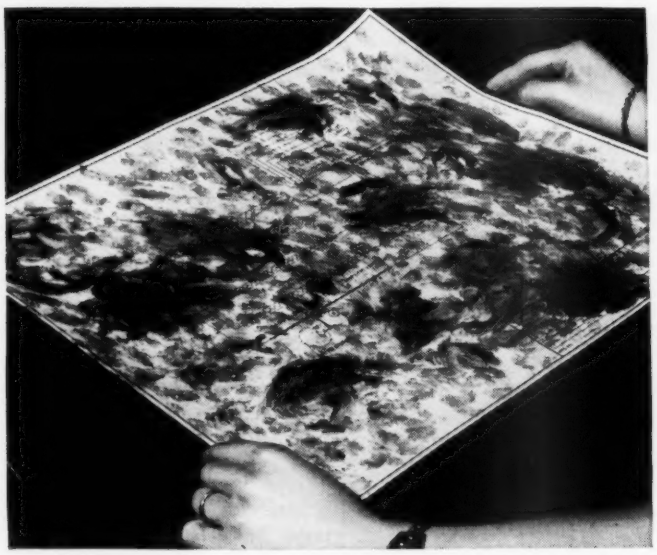
October 13-15
PORCELAIN ENAMEL INSTITUTE—Annual Forum. University of Illinois, Urbana, Ill.

October 22-25.
METAL TREATING INSTITUTE—Annual Meeting. Adelphia Hotel, Philadelphia, Pa.

Now—you can also plan your drawing's future!

Now you can plan beyond the drafting board . . . always reproduce each drawing as the type of Ozalid print best fitted for the job at hand. You can "color code"... make translucent "masters"... prints on film or plastic-coated cloth.

Always the same, simple operation—no matter what your choice. Ozalid prints are exposed and dry developed . . . in seconds. Each is an exact-size, positive copy . . . with lines and images reproduced in black, blue, red, or sepia colors.



Ozaplastic—the right print for jobs where grease and grime abound. It's oilproof, waterproof, greaseproof. You can give it a "beating"—as illustrated above—without affecting it one bit.

Just like new... by simply running a damp cloth over the print. No time out for replacements . . . no time wasted on the production line. Typical of your savings . . . when you match the print to the job with Ozalid!

NEW, FREE BOOKLET

Contains all of the Ozalid prints you can make from your drawings or other translucent originals. Explains how you save by "print-matching." Gives Ozalid machine specifications for all requirements.

Ozalid in Canada—**Hughes Owens Co., Ltd., Montreal**

DEPT. 163

OZALID A Division of General Aniline & Film Corporation
Johnson City, New York

Gentlemen: Please send free booklet of Ozalid prints . . . and machine catalog.

NAME_____ POSITION_____

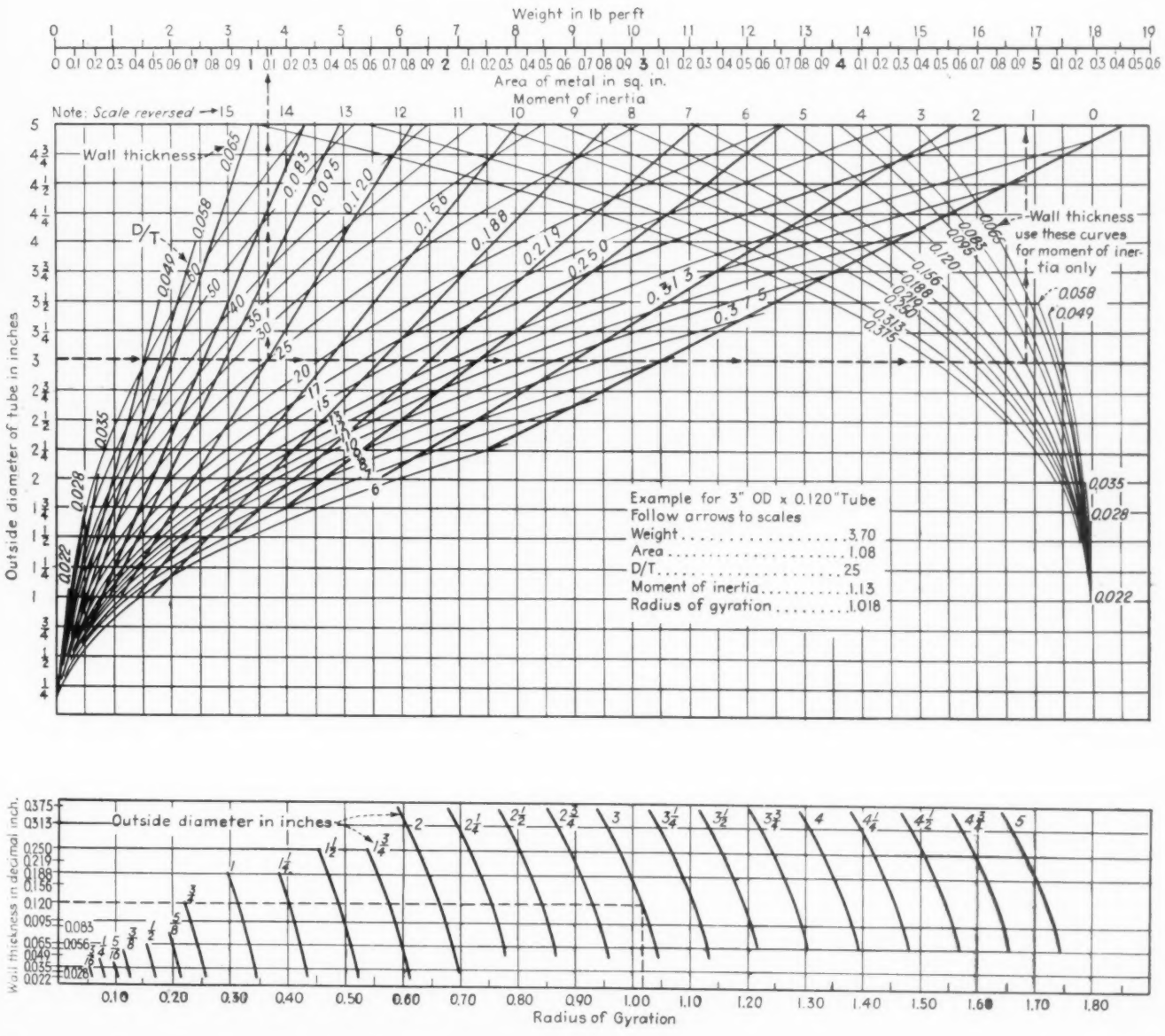
COMPANY_____

ADDRESS_____

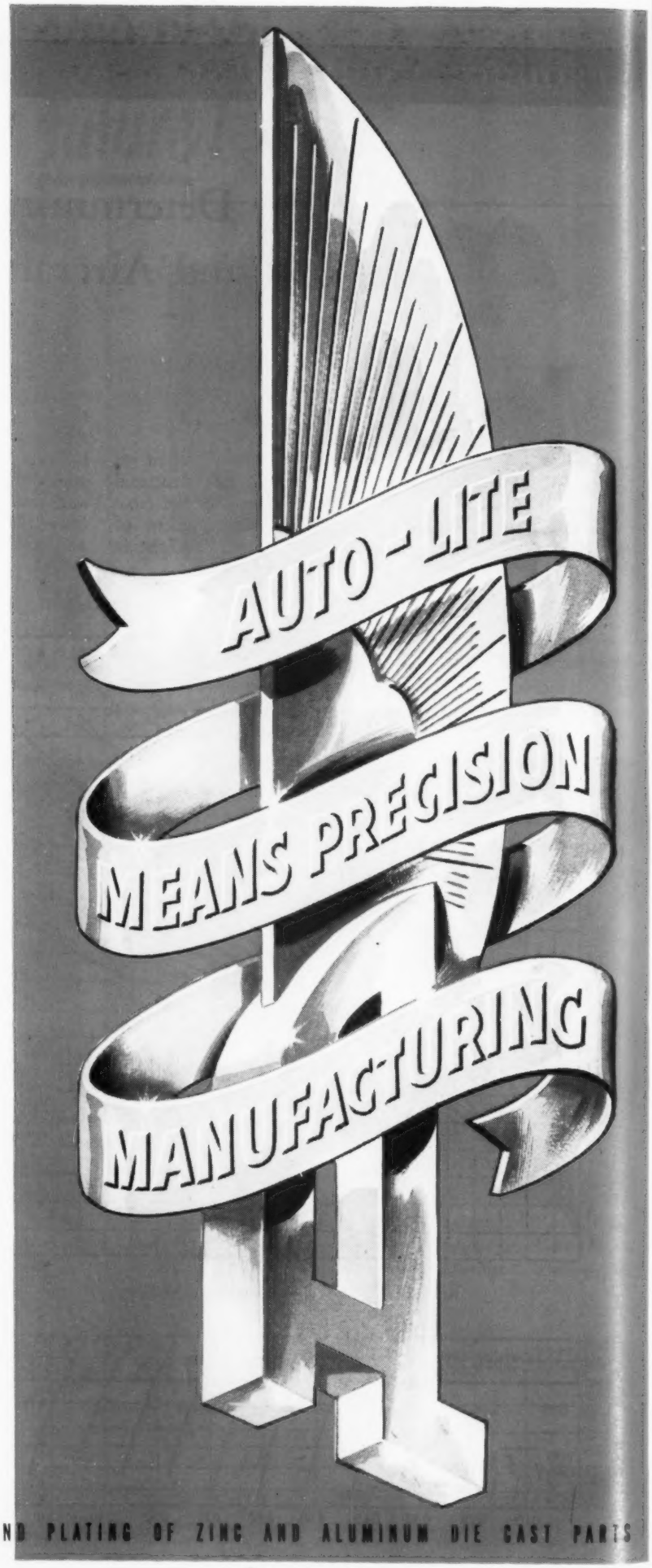
Chart for Determining Properties of Round Aircraft Tubing

BENJAMIN OSTLIND
Staff Engineer, Baker Steel and Tube Company

CHART BELOW comprises several groups of empirical curves useful for the quick determination of aircraft structural tubing properties. These include area of metal in the cross section, weight per lineal foot, D/T ratio, moment of inertia and radius of gyration. The top scale "weight in in lb per ft" is for X4130 steel only. Values for other metals can be easily figured by applying the ratio between the density of X4130 and that of the metal in question. An example is worked out on the chart. The dashed lines indicate the procedure for reading values on the various scales. Note that the "Moment of Inertia" scale is reversed and that values for radius of gyration are found in the lower block. Interpolation should be made along horizontal and vertical lines only.


Weight in lb per ft
Area of metal in sq. in.
Moment of inertia
Note: Scale reversed
Wall thickness
D/T
Outside diameter of tube in inches
Wall thickness use these curves for moment of inertia only
Example for 3" OD x 0.120"Tube
Follow arrows to scales
Weight 3.70
Area 1.08
D/T 25
Moment of inertia 1.13
Radius of gyration 1.018

Die Casting by AUTO-LITE



Manufacturers of a wide variety of products are benefitting from Auto-Lite die cast research and experience. Solid engineering, advanced casting methods, proper alloying practices and improved quality through "controlled metals" have made Auto-Lite a logical source of precision die castings.

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division
600 S. Michigan Avenue • Chicago 5, Illinois
723 New Center Building • Detroit 2, Michigan

Tune in "Suspense!", the Auto-Lite Radio Show
Thursdays, 9:00 P.M.—E.D.S.T. on CBS

CASTING, MACHINING, FINISHING AND PLATING OF ZINC AND ALUMINUM DIE CAST PARTS

Nomogram for Designing Steel Torsion Springs

CARL P. NACHOD
Vice President, Nachod & U. S. Signal Co., Inc.

DESIGNS OF TORSION SPRINGS of all types of metal depend on fixed equations entailing the same known and unknown quantities. The nomogram shown on page 169 has been prepared for use in carbon steel torsion spring design, but can be changed for use with brass, phosphor bronze, monel and stainless steel. All assumptions necessary to the preparation of this nomogram have been based on load applied as shown in sketch.

It should be remembered that as load is applied to a torsion spring in this manner, spring diameter decreases slightly, length increases. Both of these changes should be anticipated when designing springs.

Basic quantities include:

D = Mean diameter of helix, in.
d = Wire diameter, in.
r = $r_1 = r_2 = D/d$ = Ratio affecting spring proportions. It usually lies between 4 and 10.
c = Coiling coefficient—depending on r. Varies from 1.23 to 1.05 for above variation.
S' = Maximum fiber stress, psi; including coefficient c for increased stress by coiling.
S = Maximum fiber stress, psi; excluding coefficient c.
f = Rotational deflection for one-turn spring, rev.
N = Number of turns in helix.
K = T/Nf Spring gradient, lb-in./rev.
E = Modulus of elasticity (carbon steel, 30×10^6 psi.)
T = Torque, lb-in.
fN = Rotational deflection for spring of N turns, rev.
Q–Q = Common turning scale on nomogram.

Basic equations and usable forms:

$$S' = cS \quad (1) \qquad c = \frac{r - 0.2}{r - 0.9} \quad (2)$$

$$S' = \frac{1.02\,Tc}{d^3} \quad (3) \qquad f = \frac{0.34\,r\,T}{10^6\,d^3} \quad (4)$$

$$\text{Let } Q = \frac{T}{d^3} \quad (5)$$

$$\text{Then: } S' = 1.02\,c\,Q \quad (3a)$$

$$f = \frac{0.34\,r\,Q}{10^6} \quad (4a)$$

The chart was formed from Eqs (1), (2), (3a), (4a) and (5); Eq (2) being a close approximation for the relation between r and c as determined by Wahl.

When designing a spring, mean diameter, wire diameter and ratio are known, and desired torque is known. The chart is used by drawing a secant to connect the values for wire diameter and desired torque. This establishes the common point for all secants on the turning scale, Q-Q. A secant is drawn from the ratio on the r_1 scale to the turning point and extended to the maximum fiber stress scale. A third secant is drawn from the ratio on the r_2 scale to the turning point and extended to the rotational deflection scale. Values are read for the maximum fiber stress and the rotational deflection of a one-turn carbon steel torsion spring.

EXAMPLE: Find the maximum fiber stress and rotational deflection of a carbon steel torsion spring to be made from 10 turns of No. 30 music wire (0.08 in.) with a ratio of 8 and a torque of 13.2 lb-in. Also determine torque and deflection of same spring when stressed to 100,000 psi.

SOLUTION: Draw secant from 0.08 on d scale to 13.2 on T scale. Draw secant from 8 to r_1 scale through turning point and read 29,000 psi on maximum fiber stress scale. Draw secant from 8 on r_2 scale through turning point and read 0.07 rev on deflection scale. These results are for a one-turn spring. The stress will be the same for a 10-turn spring, but the deflection will be ten times as large or, 10 times 0.07 equals 0.7 rev. By simple proportion, if the same spring is stressed to 100,000 psi:

$$T = \frac{100{,}000}{29{,}000} \times 13.2 = 45.5 \text{ lb-in.}$$

$$fN = \frac{100{,}000}{29{,}000} \times 0.7 = 2.41 \text{ rev}$$

Data on construction of the nomogram is included for those who wish to modify it for use with other metals or other physical spring dimensions. In a 10 x 6.9 in. chart, the respective scale moduli and the distances between scales are, from the left:

Scale	f	d	S'	Q	r_1	r_2	T
Log M	lb. in.	6	15	6	3	6	6	7½
Distance, in.		0.4	0.6	2	2	1	0.9	

The secant joining each pair of mating scales can be thought of as a walking beam pivoted about the Q point and pin-joined to the scales. Limits of scale dimensions can be altered by sliding one scale up and the other down a corresponding amount.

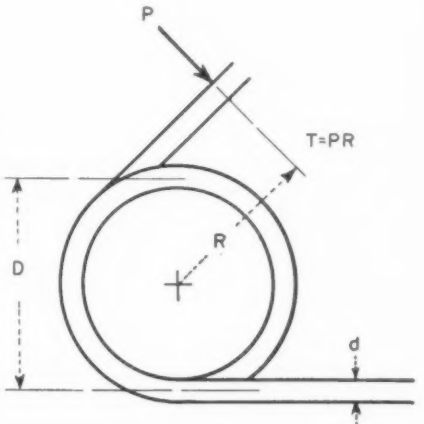
The unreduced form of Eq (4) is:

$$f = \frac{32\,T\,D}{\pi\,E\,d^4}$$

in which E occurs as an inverse. Therefore, if the rotational deflection is f' for a spring of different metal, with modulus E', then:

$$f' = \frac{30 \times 10^6 \times f}{E'}$$

where f is taken from this nomogram based on steel. Moduli of elasticity for other metals are: Brass, 14.5; phosphor bronze, 15; monel, 25.5 and stainless steel, 29 x 10^6 lb per sq inch.



(*Continued on page 169*)

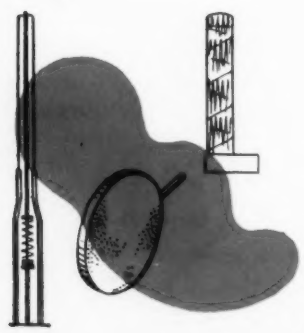
"Hybrid Metallurgy"

IMPROVES ON NATURE, TOO!

The wonders wrought by scientists in agriculture, horticulture and animal husbandry have become commonplace. By crossbreeding plants and animals, we have grapefruit, hybrid corn, heavy cattle and hogs—hundreds of marvels which Nature alone could never produce.

The same is now true in metals. Fansteel metallurgists using powder metallurgy and other techniques far beyond simple alloying, are producing "hybrid" metals which enhance desirable properties and suppress undesirable characteristics to almost any desired degree. For example, there are Fansteel metals ideally suited for current-carrying springs because of their superior elastic and electrical properties, as well as their resistance to annealing and drift. Another Fansteel metal has most of the density of tungsten, yet is easily machined, making it useful as flywheels and governors for rotational control, shields on containers for radioactive materials and similar applications.

For these metal product problems where no solution appears to exist, why not get acquainted with Fansteel metallurgy. Tell us the properties you need. We may have a metal that will meet the requirements exactly and can fabricate it to your exact specifications. Fansteel Metallurgical Corporation, North Chicago, Illinois.



PURE METALS

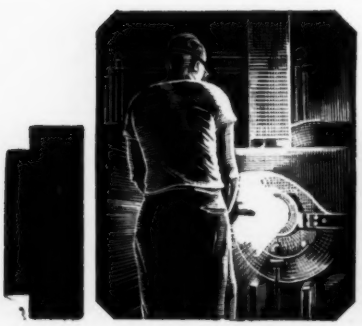
Tungsten, Molybdenum, Tantalum and Columbium in sheet, rod, wire and special shapes and parts.

POWDER METALLURGY PRODUCTS

Finished or semi-finished shapes and parts of special analysis to achieve high strength, density, electrical conductivity, resistance to wear, impact, heat, erosion, or combinations of these and other properties.

COPPER BASE ALLOYS

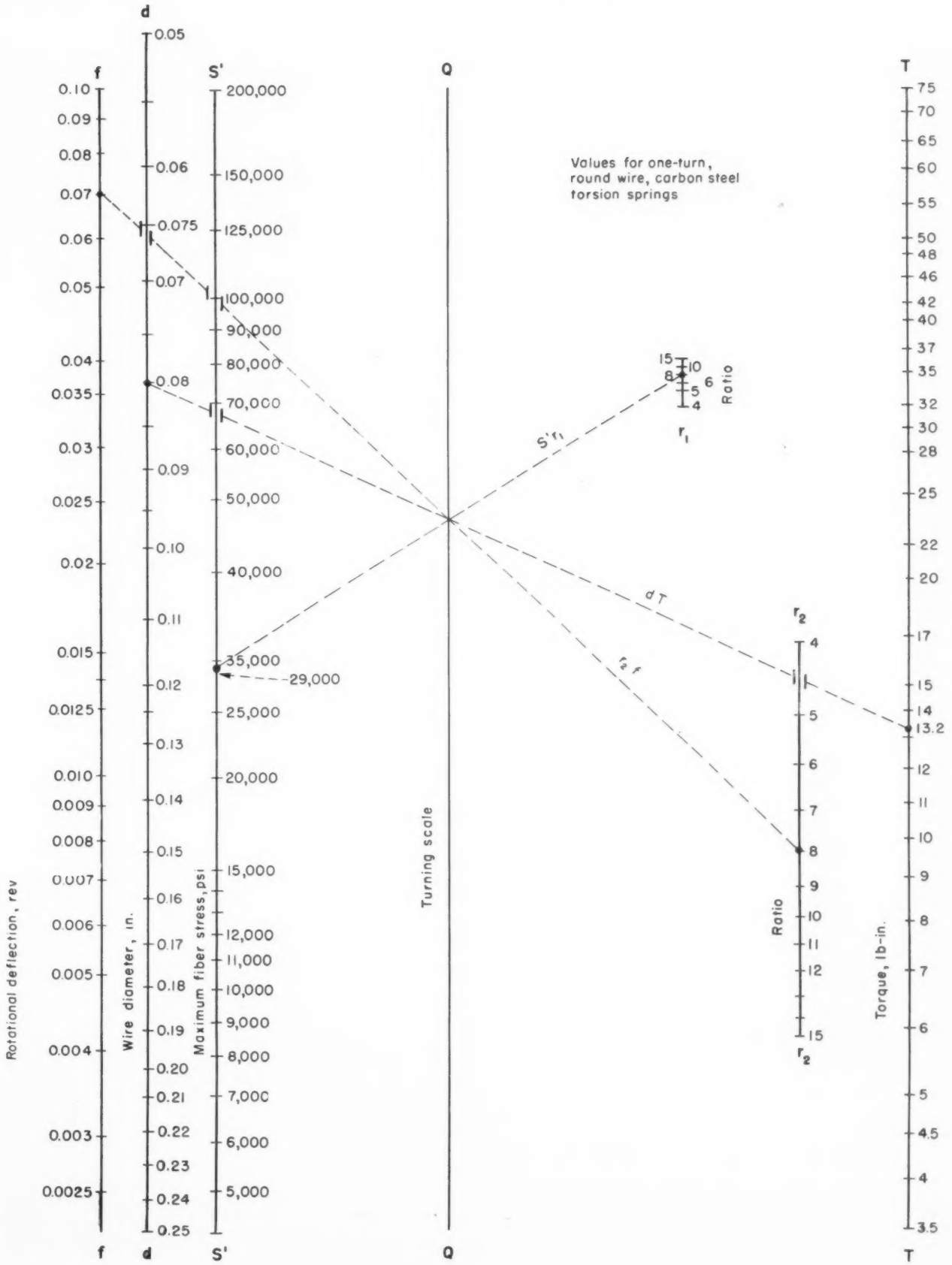
Copper alloyed with other elements, to combine high conductivity with strength, elasticity, resistance to heat, impact or wear. Available in bars, rod, sheet, strip, castings, forgings, finished or semi-finished parts, for electrical hardware, current-carrying springs, resistance welding electrodes, dies and fixtures.



Fansteel

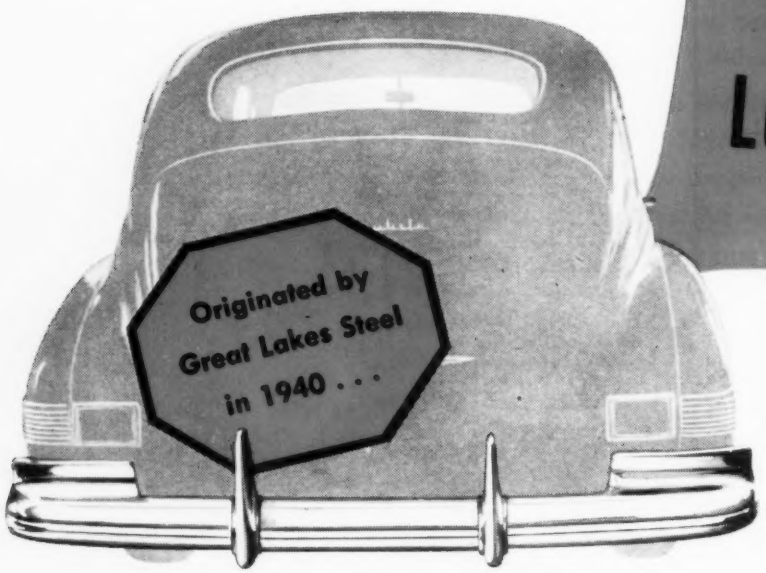
SPECIAL PRODUCTS
In Controlled Metallurgy

Nomogram for Designing Steel Torsion Springs (continued)



Another First for Great Lakes Steel

Cold-Stamped Bumpers OF High-Tensile Low-Alloy Steel



Over eight years ago the Great Lakes Steel Corporation applied N-A-X HIGH-TENSILE STEEL to the first cold-stamped automobile bumper. This represented the first practical application of high-tensile, low-alloy steel to the passenger car industry.

Today, passenger car manufacturers have universally recognized the superiority of cold-stamped bumpers which utilize the high strength, good formability, and better surface texture of high-tensile steel. Four out of five cars built today have them as original equipment – concrete evidence of the economic value of this Great Lakes Steel contribution to the automotive industry.

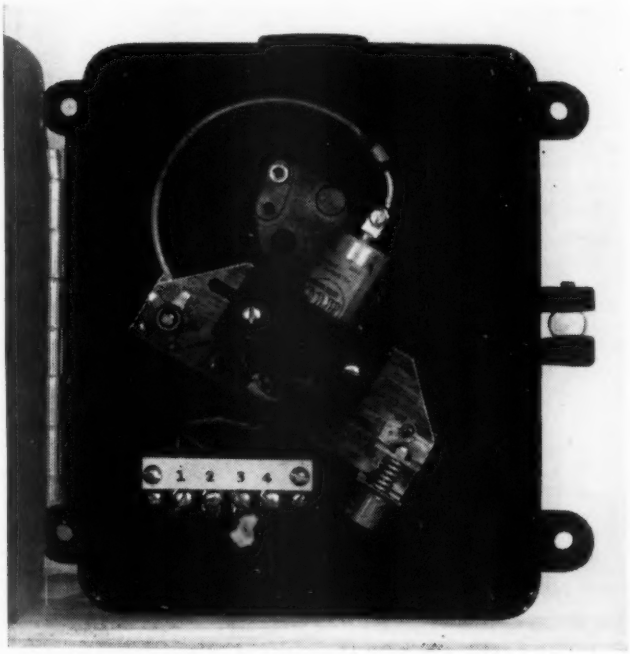
MAKE A TON OF SHEET STEEL GO FARTHER
Specify –
N-A-X
HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Detroit 18, Michigan
UNIT OF NATIONAL STEEL CORPORATION

NEW MATERIALS AND PARTS

INDEX OF ITEMS

Product	Manufacturer	Page
Belting, Conveyor	Cambridge Wire Cloth Co.	182
Bushings, Insulated	Buchanan Electrical Corp.	180
Connector, Multi-Contact	Winchester Electronics Co.	174
Couplings, Small Flexible	Climax Flexible Coupling Co.	174
Dial, Multi-Turn	Helipot Corp.	176
Gaskets, Metallic	U. S. Gasket & Shim Co.	182
Injection System, Diesel	Ex-Cell-O Corp.	180
Instruments, Bourdon	Automatic Control Co., Inc.	171
Junction Box, Compact	United Mfg. & Service Co.	176
Motors, Induction	Westinghouse Electric Corp.	172
Motor, Synchronous	R. W. Cramer Co.	180
Mount, Heavy-Duty	Lord Mfg. Co.	180
Nut, Speed	Tinnerman Products, Inc.	180
Packing, Silicone	General Electric Co.	174
Primer, Metal	Thompson & Co.	180
Pump, Small Metering	Mechanical Products Corp.	178
Pumps, Sanitary	Waterous Co.	172
Relay, Sensitive	Allied Control Co., Inc.	176
Sheaves, Variable-Speed	American Pulley Co.	178
Snap Rings, Retaining	Ramsey Corp.	172
Solenoid, Push-Pull	Phillips Control Corp.	178
Switch, Snap-Action	Acro Electric Co.	174
Switch, Motor Starting	Torq Electric Corp.	172
Tachometer Heads, Small	Metron Instrument Co.	182
Thermometer Elements	Ruge-de Forest	176
Timer, Sequence	Thermalerte Co.	182
Tubing, Plastic	William Brand & Co.	171
Valve, Lubricator	Titeflex Inc.	178
Valve, Micrometer Needle	Parker Appliance Co.	182
Valve, Pilot-Type Relief	Fluid Controls, Inc.	174



Electrical Bourdon Instruments

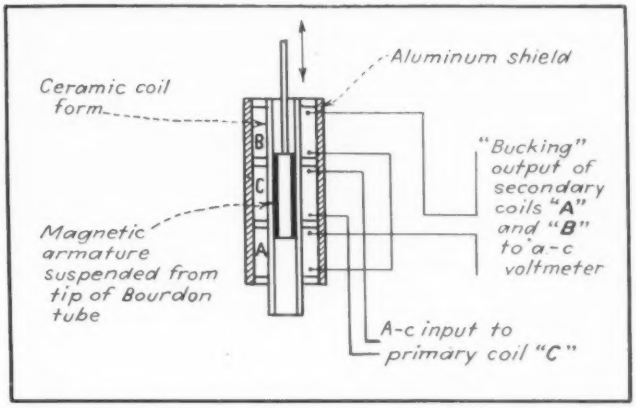
Automatic Temperature Control Co., Inc., 5212 Pulaski Ave., Philadelphia 44, Pa.

The problems of zero checking, loading to full-rated range, and hysteresis effects commonly associated with Bourdon gage instruments have been greatly reduced through the use of the Atcotran electrical pressure transmitter. In this device, Bourdon tube is not loaded with instrumentation gear such as jewel bearings, pivots and springs; and zero adjustment is made by turning the thumb screw.

Atcotran is essentially a differential transformer with a linear response. It consists of three coils wound on a single spool with a free moving armature of magnetic material mounted inside of spool. (See line cut.) Standard alternating current is supplied to the center, or primary coil "C" and the magnetic flux generated by this coil is distributed by the armature so that a voltage is induced in the secondary coils "A" and "B". If armature is symmetrically located (centered), the induced voltage will be equal but if armature moves to the left, the induced voltage in coil "A" will be greater than that induced in coil "B". If the armature moves to the right, the voltage in coil "B" will be greater.

In normal operation, coils "A" and "B" are connected in a series-bucking relationship so that, when the armature is centered and both coils have equal voltages, the resulting output will be zero. If armature moves to the left, a voltage of one phase (A) will predominate and if armature moves to the right, a voltage of the other phase (B) will predominate. Phase "A" will differ from phase "B" by 180 degrees.

Output is measured by an a-c voltmeter calibrated to read in terms of pressure, vacuum, inches of water and


Aluminum shield
Ceramic coil form
"Bucking" output of secondary coils "A" and "B" to a-c voltmeter
Magnetic armature suspended from tip of Bourdon tube
A-c input to primary coil "C"
B
C
A

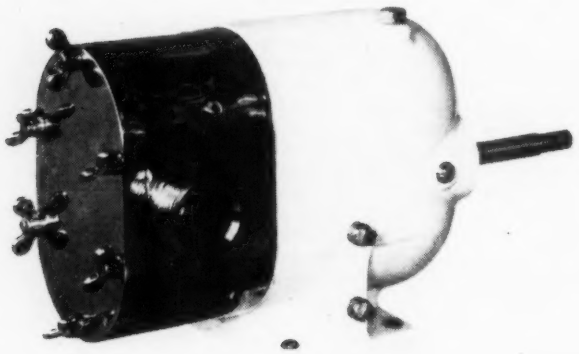
other units. Standard pressure ranges are 0—30, 0—100, 0—500, 0—1,000, 0—5,000 and 0—10,000 psi. Indicators, meters or recorders are accurate to within $\frac{1}{4}$ of 1 percent of actual reading. Any number of pressure transmitters, of either the same or different ranges, can be read from one common indicator equipped with selector switch stations.

Heat-Resistant Plastic Tubing

William Brand & Co., 276 4th Ave., New York 10, N. Y.

Turbo REL-16-A extruded thermoplastic tubing resists temperatures up to 105 C, continuous operation. Flexibility is retained after repeated baking, potting and soldering operations. Highly densified compounding provides

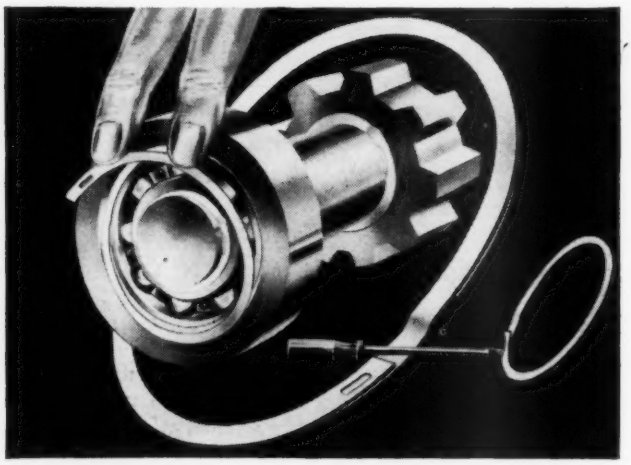
a smooth satin-like finish with minimum porosity. This characteristic makes the material applicable for transformer oil immersion and provides an expanded range of controlled wall gages. High dielectric strength and low moisture absorption are additional characteristics.



Sanitary Pumps

Waterous Co., Thomson Pump Div., St. Paul 1, Minn.

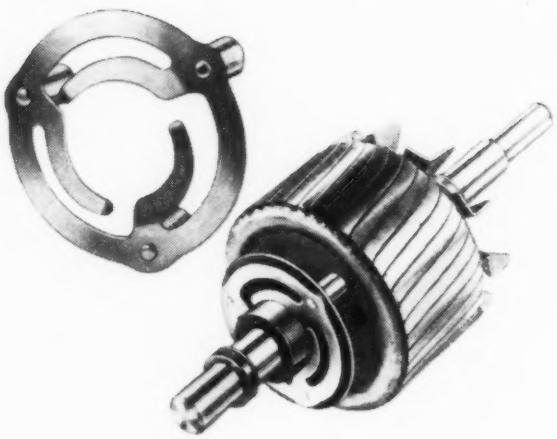
Six sizes of sanitary stainless steel centrifugal pump with capacities ranging from 1 to 125 gal are suited for applications in the dairy, food, beverage and chemical industries. Of rigid ball bearing construction with positive clearance control, pumps have no internal threads and can be quickly disassembled for cleaning. Pressures range from 100 psi for water to 250 psi for viscous materials. Smaller units operate at 100 to 600 rpm, larger ones at 50 to 450 rpm. Driving power required varies from $\frac{1}{4}$ to 10 horsepower. Port sizes for sanitary use range from 1 to $2\frac{1}{2}$ in.; standard thread sizes from $\frac{3}{4}$ to $2\frac{1}{3}$ inches.



Retaining Snap Rings

Ramsey Corp., St. Louis, Mo.

Double-turn Spirolox snap retaining rings available in all sizes can be used to position and lock pinions, bushings, bearings and related parts on shafts and in housings. Double-coil does away with conventional gap, produces improved dynamic balance and uniform bearing surface for thrust loads around circumference. Ring does not wind or unwind while under thrust loads. Device is easily removed with a screw driver.



Motor Starting Switch

Torq Electric Corp., 1080 Interstate St., Bedford, Ohio

Syncrosnap centrifugal starting switch for fractional horsepower motors consists of a stamped metal disk that carries fingers and centrifugally actuated weights. Movement of disk and fingers is preset to take place at the point of maximum torque. At critical speed, weights cause torque reaction in disk, snapping it away from rotor and breaking contact. Switch has no contact flutter and life of the assembly is said to be three times that of standard contacts or starting winding. Mechanism is featured on $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$ and $\frac{1}{2}$ hp motor assemblies.

Wound-Rotor Induction Motors

Westinghouse Electric Corp., 306 Fourth Ave., Box 1017, Pittsburgh 30, Pa.

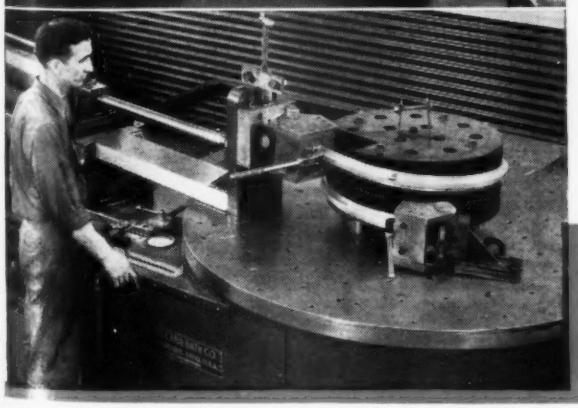
Type CWP wound-rotor Life-Line induction motors of open drip-proof construction are available in ratings of 1 to 15 hp and with frames of sizes 203 through 326. The frame is rolled from steel plate and the feet are pressed steel. Brushes are made of electro-graphite or metal-graphite depending on service requirements. Brushholders are of sliding-box type with adjustable spring tension. Collector rings are molded solidly into Moldarta insulation bushing that is pressed on the shaft. An oversize fan gives maximum air circulation and self-

Only one die instead of customary two, with BATH FORMING METHODS

...as a result, die costs are lower, and BATH PRECISION FORMING is surprisingly economical!

Stretch forming body posts, for motor buses, from rolled steel hat section material. No buckling of flanges.

Compress forming oval-shaped front body rail for trailers from steel section pre-formed on press brake.



Forming a ring from aluminum hat section, followed by trimming and joining to form a full circle.

BATH stretch, roll and wipe forming methods require but **one die**, yet part-to-part duplication is extremely accurate. Moreover, this method of cold-forming produces stronger parts than heat forming.

Many types of curves not formable on simple die equipment can be formed economically by BATH methods. Frequently it is possible to supply as a single piece, parts previously formed in several sections.

BATH also has complete facilities for brake forming, punching, offsetting, notching, trimming and other supplemental operations—so that in most cases your parts can be supplied complete for quick assembly without additional work in your plant.

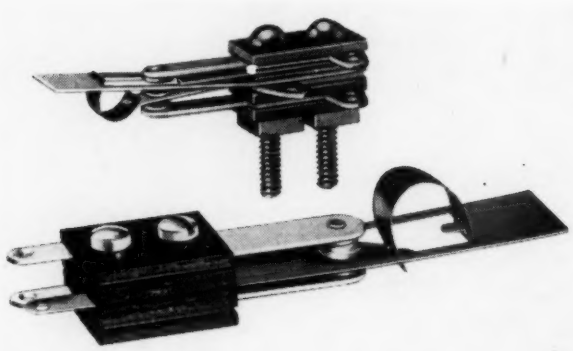
Write for booklet described below or send blueprints and engineering details.

Free Booklet

12 page booklet—with photos of production work and detailed information on wide range of cost-cutting possibilities in BATH Contour Forming—yours for the asking.

The
CYRIL BATH COMPANY.
6987 Machinery Avenue Cleveland 3, Ohio

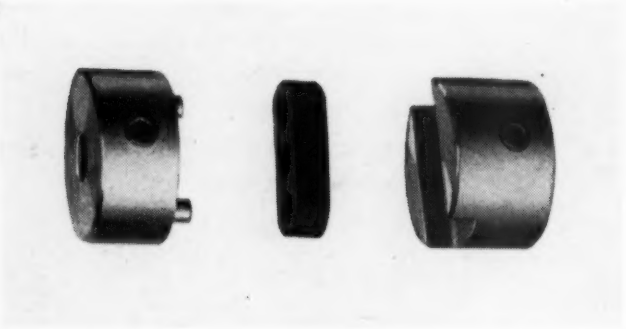
sealed, pre-lubricated ball bearings have a special sealed-in lubricant good for five years or longer. Motors can be used wherever adjustable speed is required, or where high-starting torque with low-starting current is necessary. Balanced design and sturdy construction make them especially useful for driving compressors, plunger pumps, positive pressure blowers, or for bringing heavy loads up to speed. Assemblies are available for operation at various speeds, voltages and frequencies.



Snap-Action Switch

Acro Electric Co., 1310 Superior Ave., Cleveland 14, Ohio.

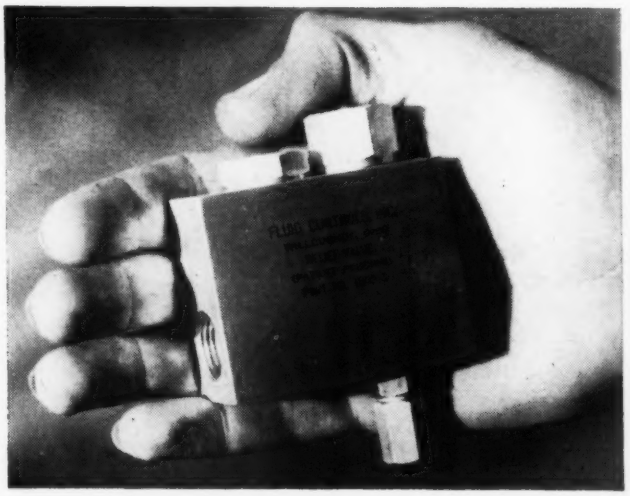
Two sizes of positive, snap-action switch embodying the rolling-type spring carry Underwriters' Laboratories rating of 15 amp at 125 v or 7½ amp at 250 v, alternating current. Single-pole, open blade assemblies are available with either return- or set-type action. Larger model has oversize contacts that provide durability during continuous operation under conditions approximating rated load. Switches can be made with various operating characteristics, as well as with blades of different forms and lengths.



Small Flexible Couplings

The Climax Flexible Coupling Co., 863 E. 140th St., Cleveland 10, Ohio

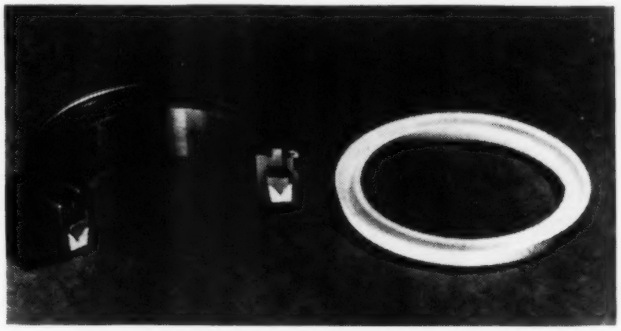
Type C-O couplings provide maximum flexibility and shock absorption for light-load electric motor applications. The two die-cast bodies engage a molded neoprene insert. Drive-pin engagement permits considerable misalignment without danger of insert extrusion. Coupling weighs 2 oz, has a diameter of ⅞ in. and a length of 1 inch. Body bores range in five sizes from ⅛ to ⅜ inch. Maximum rated capacities are 1/20 hp at 1,000–2,000 rpm, 1/15 hp at 2,000–3,000 rpm and 1/10 hp at 3,000–5,000 revolutions per minute.



Pilot-Type Relief Valve

Fluid Controls, Inc., Willoughby, Ohio

Type 1000-3 spring loaded pilot relief valve is characterized by a small differential between cracking and full relief pressure and almost instantaneous response. Aluminum alloy unit is suited to all hydraulic oils used in machine tools and material handling equipment. Weighing only 8½ oz, valve is easily supported by the connected lines. Relief pressure is adjustable between 200 and 1,000 psi or between 800 and 4,000 psi. Capacities range from 2½ to 10 gallons per minute.



Silicone Oil Seal Packing

General Electric Co., Waterford, N. Y.

The V-packing in Sealol oil seals provides good gasketing performance at temperatures up to 400 F, an increase of 200 deg above previously allowable temperatures. Though contact with hot oil swells silicone rubber stocks, this swelling is not accompanied by binding around a shaft, because surface temperature never reaches the softening point of the synthetic material. Available in a variety of extruded shapes, molded parts and fabricated stocks, this silicone can be reinforced with plies of glass and asbestos cloth to give greater strength.

Multi-Contact Connector

Winchester Electronics Co., 6 E. 46th St., New York 17, N. Y.

Seven and fifteen contact connector assemblies have telescoping barriers to provide long creepage paths. Molded melamine bodies carry machined silver-plated contacts

newest!

THE FAIRBANKS-MORSE
*axial air-gap motor!**

Here's the industry's newest electric motor, the most radical improvement in the design of standard rating 40-degree motors since their earliest days!

The Axial Air-Gap Motor offers opportunities heretofore beyond reach of those designers interested in conserving space, reducing headroom, cutting weight—and in improving the appearance of their product.

Write for Bulletin 2760—it has the information you'll be wanting.
Fairbanks, Morse & Co., Chicago 5, Ill.

***Air-Gap dimension is measured parallel to the axis of the shaft. Horizontal and vertical mountings; also, pivot base mountings. Polyphase squirrel cage and capacitor start, single phase types.**

The Axial Air-Gap Motor has hundreds of applications . . .

PRESSES

REDUCERS

SHAPERS

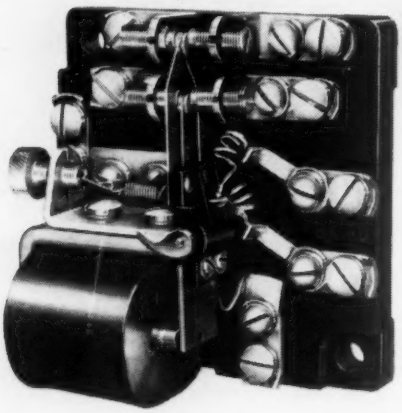
Ask your Fairbanks-Morse Electrical Expert!

FAIRBANKS-MORSE

A name worth remembering

DIESEL LOCOMOTIVES • DIESEL ENGINES • STOKERS • SCALES • MOTORS • GENERATORS
PUMPS • RAILROAD MOTOR CARS and STANDPIPES • FARM EQUIPMENT • MAGNETOS

that insure low resistance, freedom from corrosion and ease of soldering. Aluminum hood with cable clamp fits either end of the assembly. Connector is especially suitable for military and industrial applications where minimum weight and bulk consistent with electrical requirements are required. Breakdown voltage between contacts is 7,500 d-c and 5,300 a-c; flashover distance between pins is 7/32 inch.



Sensitive Relay

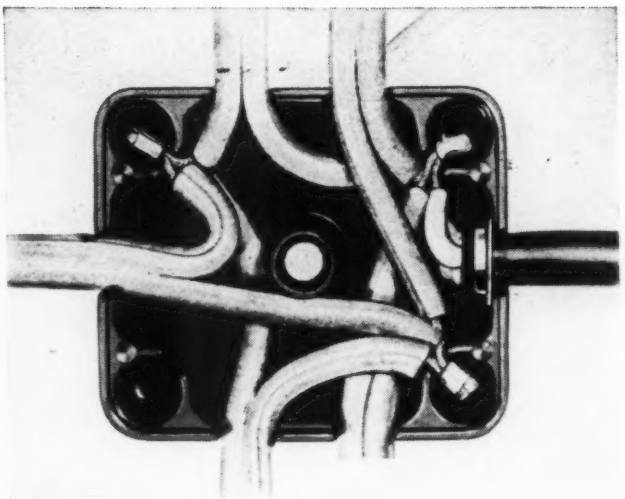
Allied Control Co., Inc., Dept S2, East End Ave., New York 23, N.Y.

Type BK relay is recommended for use under conditions of limited power supply and where precise operating characteristics are essential. Insulating parts are molded bakelite and accessible contact screws permit fine adjustments. Single or double throw, one or two pole units are available with normally open or normally closed contact arrangements. Coil ratings are 32 v d-c at 24 milliwatts, or 220 v, 024 va; contact ratings are 1 amp at 48 v, or 5 amp at 110 v, non-inductive. Dimensions are $2\frac{5}{8}$ in. square by 1 21/32 in. high.

Thermometer Elements

Ruge-de Forest, 76 Massachusetts Ave., Cambridge 39, Mass.

Bonded wire resistance thermometer elements are characterized by high stability, accuracy and rapid response. Known as RdF Stikon, these elements are an outgrowth of Ruge de Forest's extensive work in the development of bonded wire strain gages. Essentially they consist of a grid of fine nickel wire bonded into a paper-thin Bakelite wafer. Bakelite cement is used to attach the wafer to the surface under test. All Stikon elements are within the tolerances permitted by specifications. The exact deviation of each element from standard is given for 70 F, thus making the unknown ± region considerably smaller than that of the common resistance bulb. Operating range is from −40 to +300 F. The physical and electrical characteristics of these elements make them useful for measurement or control in industrial processes and laboratory investigations as well as for temperature-sensing elements in instrument applications. They are also well suited to measurement of temperatures on rotating shafts and propellers, since they can be used in conjunction with slip rings.



Compact Junction Box

United Mfg. & Service Co., 783 N. Water St., Milwaukee, Wis.

Nu-Blok electrical junction block minimizes danger of short circuits caused by faulty soldering or stray strands of wire. Splice connections are isolated in circular cells at each corner of the $2\frac{1}{2}$ x 2 in. phenolic case and restrained by the narrow slot in the wall of each cell. Eyelet secures laminated phenolic cover in place and serves as a channel for a No. 10 self-tapping mounting screw. All parts are made to conform with Underwriters' dimensional, dielectrical and heat resistant standards.

Multi-Turn Dial

Helipot Corp., 1011 Mission St., S. Pasadena, Calif.

Simple and accurate in operation, Duodial can be used for controlling mechanical feeds that operate on a threaded principle and with a variety of helically wound electronic devices. In the latter application, dial registers both angular position of slider contact on any given helix and position of slider along the helical winding. Of all-metal construction, device has no worm gears thus permitting hand

WANTED: A quick-drying, oil-resistant finish to apply to bearing housing castings before machining.

Advance meets Link-Belt's needs

For more than 15 years, the Advance Paint Company has been solving the finishing problems posed by the varied products manufactured by the Link-Belt Company at its two Indianapolis plants.

For example, the housings for bearings made by Link-Belt's Dodge Works require a finish that can be applied to castings just as they come from the foundry. The finish must dry instantly for immediate handling, and, most important, must be oil resistant for machining which follows the finishing operation. A quick-dry enamel formulated by Advance for this particular job meets all these requirements.

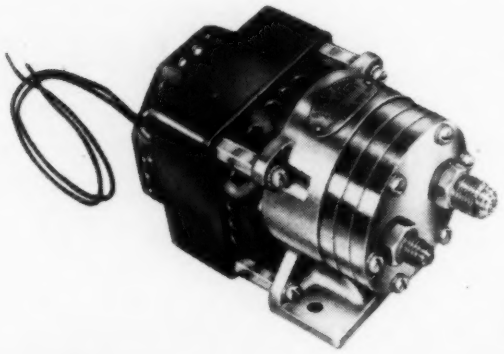
At its Ewart Works, Link-Belt finishes sprockets with a quick-drying Advance lacquer, while an Advance black dipping finish is used on steel Link-Belt for agricultural use.

No matter what you manufacture, Advance can give you the same complete finishing service. An Advance finishing technician will study your production problems and provide a finish which will meet every requirement of the job.

Manufacturers of Industrial Finishes

Advance PAINT COMPANY
INDIANAPOLIS, INDIANA

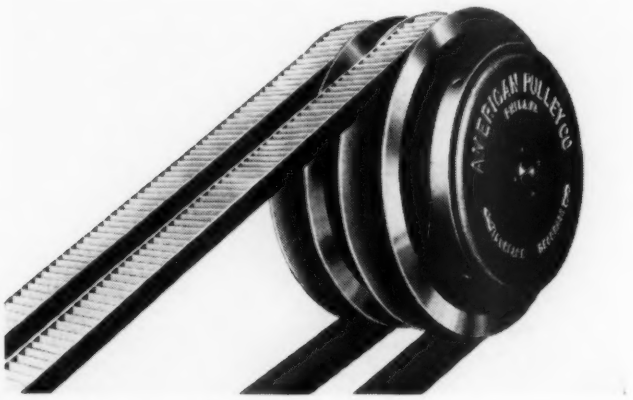
operation from knob end or power auctuation from shaft end. Adaptable to a $\frac{1}{4}$ in. dia shaft, dial is 2 in. in diameter and available with 10:1, 15:1, 25:1 and 40:1 turn-ratios.



Small Metering Pump

Mechanical Products Corp., Dept., PE 168 N. Ogden Ave., Chicago 7, Ill.

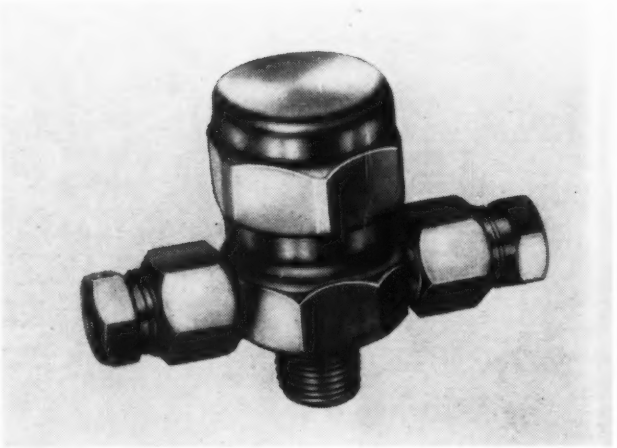
Compact motor-driven metering pump provides uniform discharge of beverage syrups and most corrosive liquids. Special valving insures instantaneous discharge and prevents dripping or leakage when motor is not operating. Standard pump has capacity of 10 cc per sec and is driven from a 1/35 hp shaded-pole induction motor on 115 v 60 cycle current. Reduction gears insure positive operation of the pump. Complete unit fits a space 4 in. square by $6\frac{1}{2}$ in. deep; weighs 7 pounds. Directly connected to reservoir, assembly permits open tank storage with direct discharge into receiving receptacles.



Variable-Speed Sheaves

The American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa.

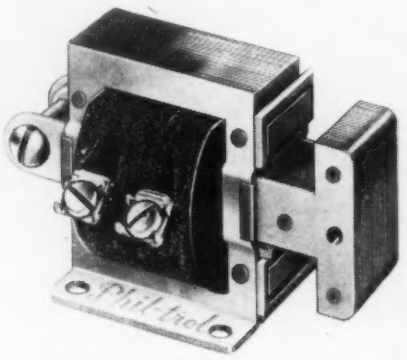
Rubber lagging bonded to the hub acts as an insulating cushion and prevents freezing of sheaves in adjustable-speed drives. Special gearing and stainless steel locking screw provide positive adjustment of all flanges simultaneously. Wide-range sheaves are made with two or three grooves having a pitch diameter variation of 5.25 to 10.0 inches. This wide range provides four to five times the speed variation available with standard adjustable-diameter sheaves. Units are designed to utilize multiple "R" section V-belts and will handle loads up to 15 horse power.



Lubricator Valve

Titeflex Inc., 518 Frelinghuysen Ave., Newark 5, N. J.

Grannan lubricator valve dispenses all types of lubricant from light oils to heavy greases without alteration. Fully hydraulic, device is installed directly into machinery bearings and will function either with hand-operated guns or from a completely automatic system set to operate at predetermned intervals. Operating temperature range is from 0 to 300 Fahrenheit. Several hundred bearings can be lubricated in approximately one minute while machine is operating. Applications include trucks, road machinery, mining equipment, farm machinery and machine tools.



Push-Pull Solenoid

Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill.

Type 51A Solenoid features a frame of firmly bonded silicon steel laminations and a T-shaped laminated plunger adaptable for both push and pull operations. Shading rings and precision ground pole faces insure quiet operation on a-c current. Smooth, dependable operation is assured by non-magnetic stainless steel side plates on the plunger and special brass plunger guides installed inside the frame. Unit is available for continuous duty on 115 v, 60 cycle current, with a maximum stroke of one inch. Approximate pull: 2 lb at $\frac{3}{4}$ in. stroke; 3.4 lb at $\frac{1}{2}$ in.; 4.2 lb at $\frac{1}{4}$ in.; over 17 lb sealed. Coil can be wound for other a-c voltages or provide more pull where the duty cycle is intermittent. Overall dimensions are: $3\frac{1}{2}$ in. long by $1\frac{7}{8}$ in. wide by 1 15/16 in. high.

Why most designers specify

Crane piping equipment

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

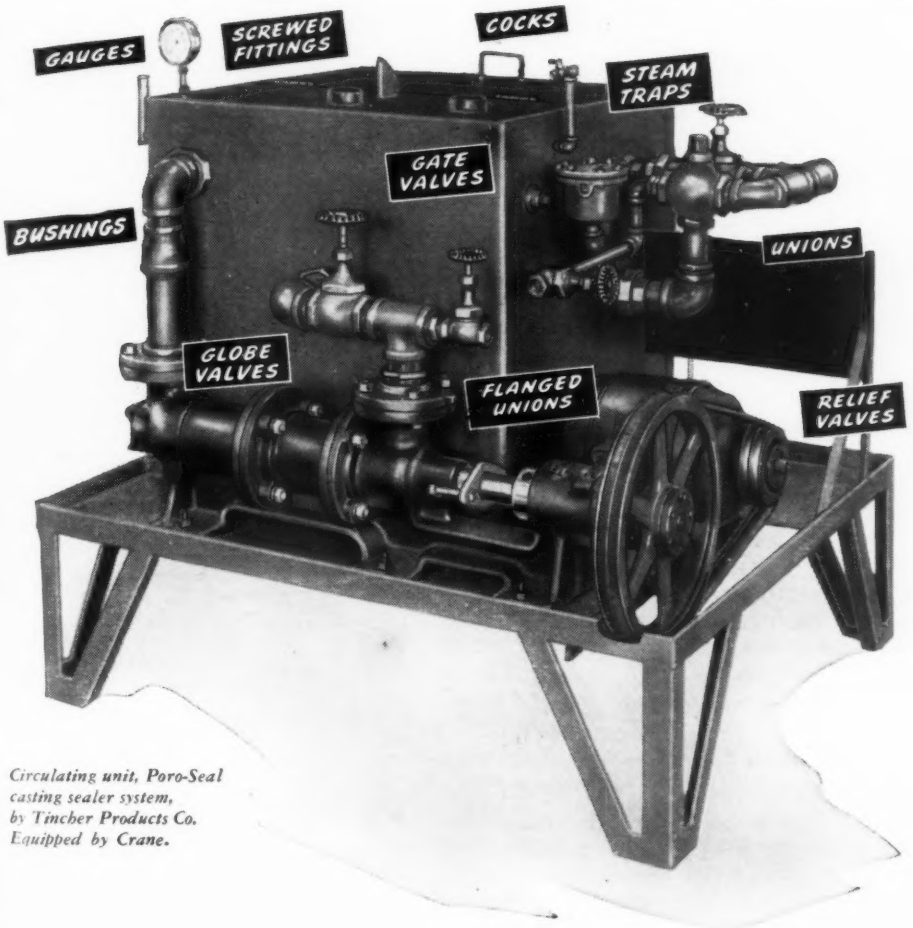
When buyers see the Crane name of flow-control equipment, they know that they are getting the best. When the best is also the easiest to specify, it's clear why so many piping "specs" say: *Crane or Equal.*

Specifying from the Crane line gives you a complete selection of valves, fittings, accessories and pipe . . . in brass, iron, steel or alloys. There's no need to search further, everything's in one catalog.

Having Crane supply all piping equipment means time saved in your drafting room . . . ordering and storing are simplified . . . piping assembly operations go smoother. And Crane equipment means *easy-to-get* replacements in the field, from Crane Branches everywhere.

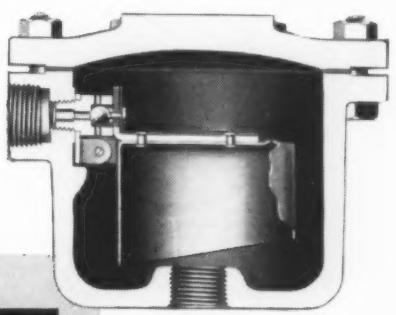
Flow control equipment is too important to use anything but the best . . so specify Crane . . . dependable for more than ninety years.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



Circulating unit, Poro-Seal casting sealer system, by Tincher Products Co. Equipped by Crane.

SIMPLIFIED STEAM TRAP, CRANE No. 981 *has only one moving part. Keeps steam lines hot and dry; saves fuel. Works automatically; requires virtually no maintenance. Compact design; ideal for steam-heated or steam-operated machinery. Easy to install and service. Made in 150, 200 or 300-pound steam pressure classes. See your Crane catalog or write for literature.*



EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

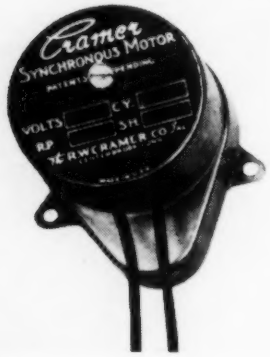
CRANE

FOR EVERY PIPING SYSTEM

Insulated Bushings

Buchanan Electrical Products Corp., 2 W. Jersey St., Elizabeth 4, N. J.

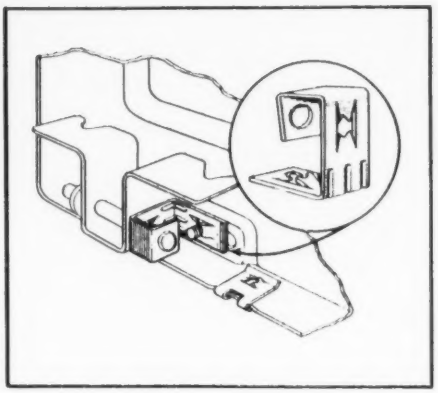
Bushend insulated metallic conduit bushings provide absolute protection against abrasion of cable insulation and accidental grounds. Fittings require no inside locknuts as is the case with units constructed wholly of insulating material. Bases are fabricated from tough, corrosion resistant, wrought alloy of high mechanical strength. Threads are free, clean-cut and non-seizing. Knurls are extra deep to facilitate tightening even in restricted locations. Insulation is permanently secured in base, has high dielectric strength and resistance to moisture absorption. All sizes are approved by Underwriters' Laboratories.



Synchronous Motor

The R. W. Cramer Co., Inc., Centerbrook, Conn.

Type SX self-starting motor reaches synchronous speed within ½ to 2 cycles and will stop almost instantaneously. Measuring 2⅜ x 2⅛ x 1½ in., motor produces 30 oz-in. torque at 1 rpm, 60 cycles, for speeds slower than 10 rpm; or 20 oz-in. at 1 rpm, 60 cycles, for speeds above 10 rpm. Interchangeable gear trains provide output shaft speeds ranging from 60 rpm to one revolution per day. Motor has friction clutch that permits rotation of drive shaft in either direction. Applications include timing devices, recording instruments, clocks, heating controls and signaling systems.



Speed Nut

Tinnerman Products, Inc., Cleveland, Ohio

The use of special speed nuts permits complete bench assembly of a cooking range oven door. The nuts, which house the hinge pins, are first fastened loosely to the door liner with the hinge pins passing through holes in welded support brackets. Slotted holes in liner permit hinge pins to be drawn inward to give clearance for positioning of door. Pins are then pushed into the hinge bracket holes and the screws tightened. Oven door can be removed when necessary simply by loosening the screws and sliding the pins out of the hinges.

Metal Primer

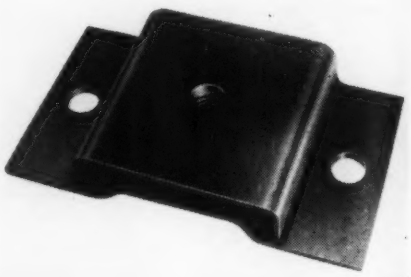
Thompson & Co., Oakmont, Pa.

Vinsynite metal primer has unusual adhesive powers and is extremely economical to apply. Because it can be applied on damp or slightly oily surfaces without degreasing and still bound to the metal, it does not require pre-treatment with etching solutions or solvent washes. Vinsynite contains no toxic pigments and, since it is an air-dry coating that can be applied by spray or brush, production processing does not have to be done. It inhibits corrosion and at the same time serves as a perfect foundation for paint, varnish, lacquer, and enamel.

Diesel Injection System

Ex-Cell-O Corp., Detroit 32, Mich.

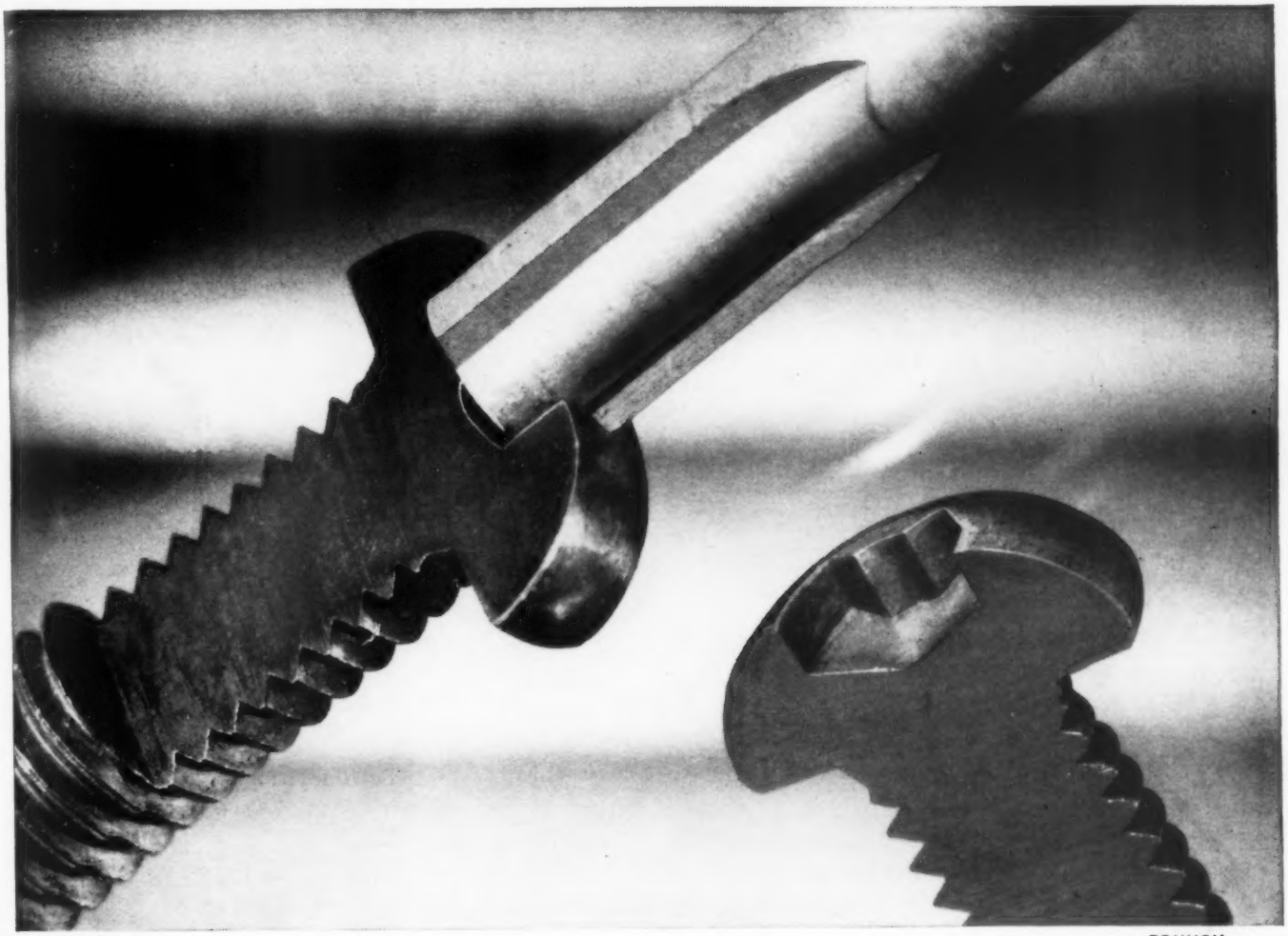
Model S single cylinder fuel injection pump and nozzle are designed for use on one-or two-cylinder diesel engines in the 5 to 15 hp range. Plunger diameters vary from ¼ to ⅜ in., depending on requirements of the particular engine. All drain lines have been eliminated from this injection system, making it positive acting and trouble free. Nozzle is calibrated and adjusted after assembly and nozzle holders can be made to specification.



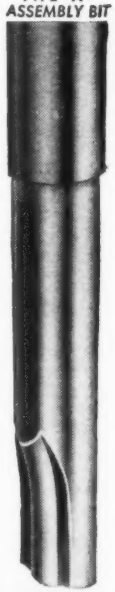
Heavy-Duty Mount

Lord Manufacturing Co., Erie, Pa.

Three sizes of heavy-duty Shockmounts are designed to control shock, isolate high frequency vibration and reduce transmission of machinery noise to the floor. It is claimed that this type mount reduces the need for massive foundations to achieve inertia and permits placing of heavy machines in locations ordinarily considered impractical. Constructed of 3/16 in. steel, unit stands 1 3/16 in. high and



TYPE "A" ASSEMBLY BIT



THE INSIDE STORY OF CLUTCH HEADS

Here It Is, showing *what* goes on inside the Clutch recess, and *why* . . . why users testify so freely that CLUTCH HEAD has features not matched by any other screw on the market for safety, speed, and savings.

Visibility a Speed Factor. The wide, roomy Clutch invites operator confidence. Saves "breaking-in" period. Presents an easy-to-hit target for stepped up production.

No Driver Canting to chew up heads and create a skid hazard. The Center Pivot Column on the Type "A" Bit guides the driver into the mating recess formation. Deep dead-center entry and straight driving become automatic.

Safe, Effortless Drive-Home. Note straight sides of the driver matching straight walls of the Clutch recess. Contact is all-square on a broad pressure area for positive torque grip and non-tapered driving.

No Ride-Out to Combat. This feature disposes of "kick-out" as set up by tapered driving . . . the commonest cause of driver slippage. The screw rides home easily without the application of fatiguing end pressure.

Lock-On Breaks "Bottlenecks". A reverse turn of the bit in the recess unites screw and driver as a unit for easy one-handed reaching to hard-to-get-at spots. Normal driving of the screw releases the Lock-On.

Sample screws and Type "A" Bit sent on request

COMMON SCREWDRIVER

"Outlasts Other Bits 5 TO 1"

The rugged structure of this Type "A" Bit logically explains this testimony. Also, a 60-second application of the end surface to a grinding wheel repeatedly restores it to original efficiency. No expense. No delay.

CLUTCH HEAD · SCREWS ·

Simplifies Field Service

This is the only modern screw basically designed to operate with an ordinary screwdriver. With a Type "A" hand driver, the Lock-On feature permits the withdrawing of screws undamaged and held safely for re-use.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

has a load carrying capacity of 7,500 pounds. Top-plate contour reduces tendency for oil and dirt accumulation and flexing element is made from oil-resistant synthetic rubber. Center hole is tapped for $\frac{5}{8}$ in. bolts.

Small Tachometer Heads

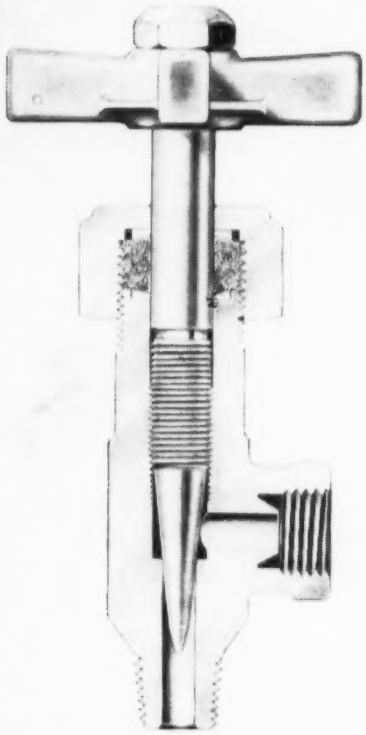
Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

Type 54 light weight tachometer heads are suitable for use with standard SAE marine, diesel and AN aircraft tachometer take-offs. When connected to standard indicators, units give full scale readings as low as 200 rpm and as high as 10,000 rpm. Operating on a contact principle, heads contain no gears, magnets or brushes to wear out or age. Shaft is mounted in permanently lubricated ball bearings. Running torque is 1/20 oz-in. for high-speed types and $\frac{1}{8}$ oz-in. for low-speed types. Weight is 10 oz, diameter is $2\frac{1}{8}$ in. and overall length is $4\frac{3}{8}$ inches.

Metallic Gaskets

The U. S. Gasket & Shim Co., 203 Hibbard Bldg., Cuyahoga Falls, Ohio

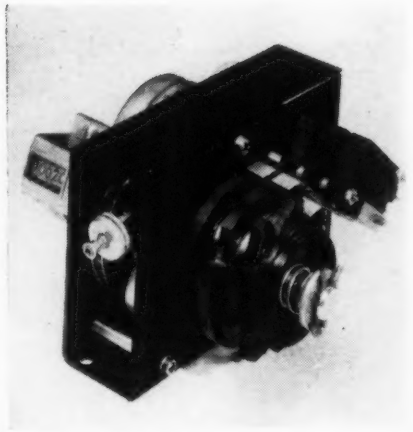
Metallic gaskets that are applicable to every field of industry using liquid and gas service equipment will withstand temperatures up to 850 F and pressures as great as 1,500 psi. Fabricated of light gage brass, copper, lead, nickel, monel, and other ferrous and nonferrous materials, they are filled with a soft asbestos to provide maximum sealing and protection against extreme pressure, heat, and corrosion. Seal is effected by the yielding, or flow, of the gasket material into the imperfections of the separable mechanical assemblies. Metallic gaskets are available in any size or shape for use in the fabrication and reassembly of high-pressure industrial boilers, in refining industries, in chemical plants and for application in plastics, zinc, lead, tin, and other high and low pressure die-casting machines. Location of bolt holes is held to 0.015 in. tolerances.



Micrometer Needle Valve

The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio

Micrometer needle valve for the sensitive metering of fluids and gases is a modification of the company's compact, forged-body industrial valve. Redesign has 5/16-40 steam threading for close adjustment and a long 10 deg included-angle, tapered needle for fine metering. Standard unit is made of high-strength brass, but aluminum alloy bodies can also be supplied. Needle stems are machined to close tolerances in Duronze and premolded packing insures a long-life stem seal. Valve is available in $\frac{1}{8}$ and $\frac{1}{4}$ in. sizes, with eight port combinations of male and female, pipe and tube connections.



Sequence Timer

Thermalerte Co., Box 605, New Haven, Conn.

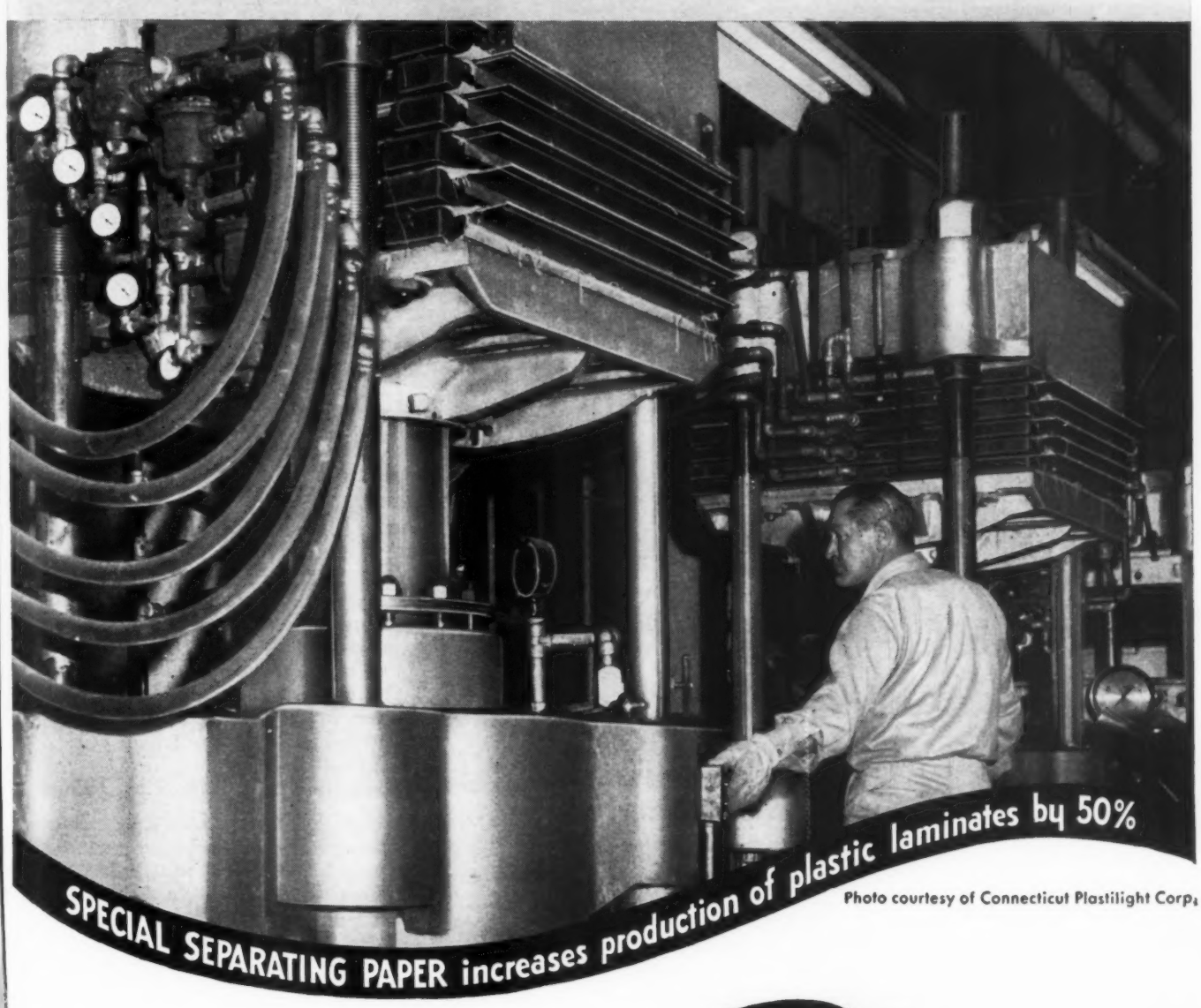
Adaptable for a wide variety of timing cycles, multi-speed sequence timer is suitable for both test and research use. Semi-enclosed compact assembly consists of a synchronous motor, counter, adjustable ratchet and three removable cams that actuate double-throw switches. Self-starting motor has speed of 1 rpm, giving continuously cycling timing interval from 1 to 36 minutes. Movement of cam shaft is governed by lost-motion ratchet system having a 36-tooth wheel. Position of speed knob on ratchet rod indexes pawl for either 1, 2, 3 or 4 teeth per motor revolution. Each of the three molded cams can be cut to have up to twelve notches. Cam-stack is spring loaded permitting manual adjustment or quick removal. Permanent settings can be maintained by interlocking cams with screws placed through the webs.

Conveyor Belting

Cambridge Wire Cloth Co., Cambridge, Md.

Woven wire conveyor belt permits continuous movement of work through industrial washing, drying, heat-treating or cooling machines used in low or high temperature processes. Design combines maximum belt strength with maximum open area. Mesh size can be controlled to provide up to 87 percent open area, while coiled construction utilizes maximum strength of the metal from which the belt is made. Large openings are extremely useful in industrial washing machines, as wash water or spray can be directed from above or below the belt and passes freely over the work, draining readily back into the wash tank. Belt can be manufactured from any metal or alloy, to a wide variety of meshes for either sprocket or roller drive.

Engineered Papers
RIEGEL-MADE TO YOUR SPECIFICATIONS



SPECIAL SEPARATING PAPER increases production of plastic laminates by 50%

Photo courtesy of Connecticut Plastilight Corp.

In each opening of these laminating presses there's a sheet of special Riegel Paper with the job of *preventing* the laminated table tops from sticking together—thereby boosting production by 50% as compared with previous separators.

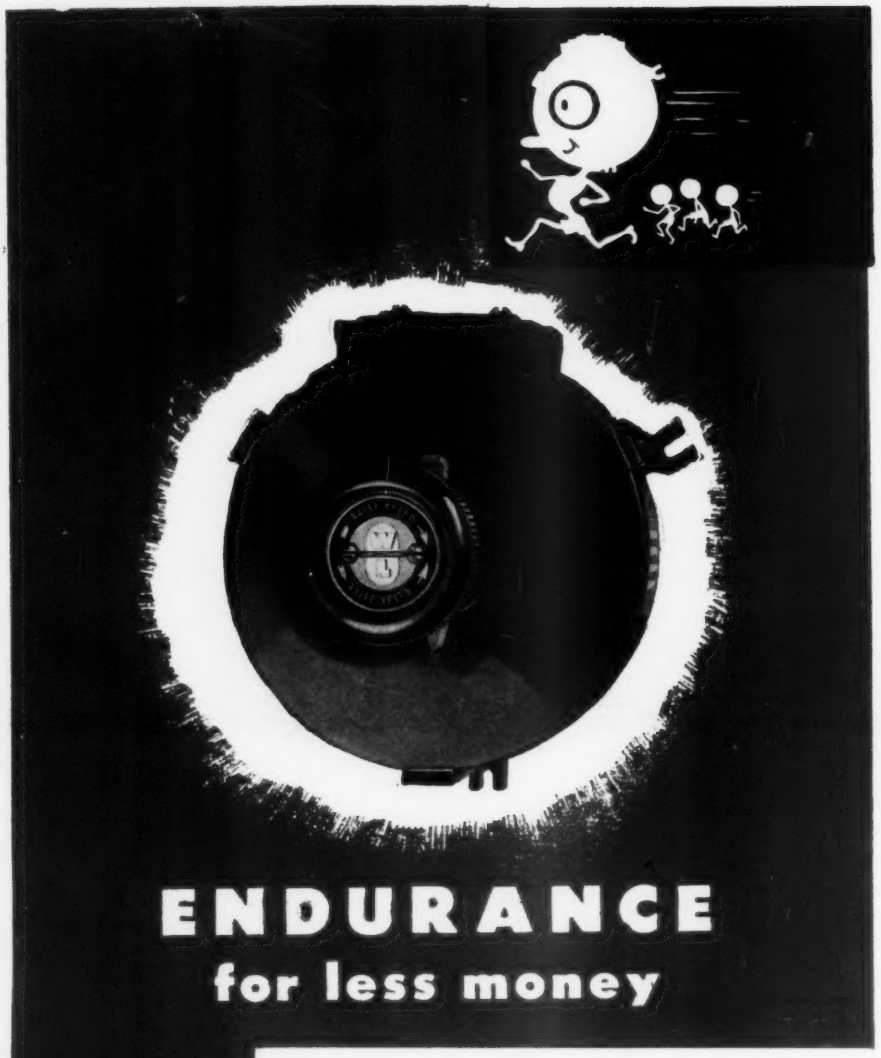
Surprising—the things being done with paper! It's a remarkably versatile and economical material that Riegel knows how to "tailor-make" to your own most exacting requirements. We can either duplicate an existing grade or develop something entirely new.

Riegel now produces over 600 papers for industrial leaders in many different fields...beaming, gasket, saturating, greaseproof, shot-shell, button stock, insulating, template...some grades made for hundreds of customers, some for but a single firm. Always consult Riegel first for any special packaging or industrial paper. If we can't make it, we will gladly tell you who can.

Riegel

Producers of technical papers for industrial leaders since 1862

Riegel Paper Corporation • 342 Madison Avenue, New York 17, N. Y.



ENDURANCE
for less money

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

Construction of Ward Leonard Vitrohm Rheostats permits use of smaller sizes

A large number of solid rectangular contacts, imbedded in vitreous enamel on a pressed steel base, fit Ward Leonard Rheostats for high watt capacity and long, continued service. Size for size, no other rheostat will perform a similar duty.

Ward Leonard Rheostats are "Result-Engineered". By modifying a basic design, Ward Leonard can often give you the results of a special . . . for the price of a standard.

Write for Rheostat Catalog. Ward Leonard Electric Co., 63 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

NEW BOOKS

Vibration and Sound

PHILIP M. MORSE, *Director, Brookhaven National Laboratory. Second Edition.* 468 *pages,* $6\frac{1}{4}$ x $9\frac{1}{8}$ *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $5.50.

Ultrasonics and microwave developments, stimulated by wartime urgency, have created a broadened audience for the general theory of wave motion. This second edition reflects these developments by including more detail on radiation problems and by introducing the subjects of transient phenomena and operational calculus.

Admittedly, the book is aimed at the physics and communications engineering student. But there is no doubt that buyers of domestic and industrial equipment are becoming more noise conscious. Design engineers who are faced with acoustic problems will find this book gives them excellent theoretical background.

Chapter subjects include the simple oscillator, the flexible string, the vibration of bars, membranes and plates, plane waves of sound, the radiation and scattering of sound, and standing waves of sound. The more difficult parts are segregated at the end of each chapter so that they need not be tackled at first.

Centrifugal and Axial Flow Pumps

A. J. STEPANOFF, *Development Engineer, Ingersoll-Rand Company; also Melville Medalist* 1932, *A.S.M.E.* 428 *pages,* 6 x 9 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $7.50.

Progress in the design and application of centrifugal pumps has been made possible by the many theoretical and experimental studies conducted by numerous investigators. Subjects covered in these studies include: Cavitation, operation outside the normal head-capacity and speed range, axial and radial thrust, effect of stuffing boxes on the critical speed of pump shafts, control of head-capacity, and pumping viscous liquids.

The theoretical treatment of the centrifugal pump impeller presented in this volume deviates materially from that found in most texts on the subject. The new method of attack is based on: A single pattern of flow; identical theoretical reasoning; and similar procedure of impeller layout for centrifugal, mixed flow, and axial flow pumps.

Among the subjects discussed in the

eighteen chapters are: Selected topics from hydraulics; theory of the centrifugal pump impeller; vortex theory of Euler's head; specific speed and design constants; design of mixed flow impellers; leakage, disk friction, and mechanical losses; cavitation; shaft design for critical speeds; special problems and applications; and centrifugal-jet pump water systems.

To aid the reader in selecting material for further study, numerous references to literature are presented throughout the volume.

Proceedings of the Society For Experimental Stress Analysis

Edited by C. LIPSON, *The Detroit Testing Laboratory, and* W. M. MURRAY, *Massachusetts Institute of Technology.* 159 *pages* 8½ x 11 *in. Published by Addison-Wesley Press, Inc., Kendall Sq., Cambridge* 42, *Mass.* $6.

This year's collection of papers includes:

The Measurement and Interpretation of Post-Yield Strains.

On the Removal of Time Stresses in Three-Dimensional Photoelasticity.

The Development of a Technique for Testing Stiff Panels in Edgewise Compression.

An Evaluation of Some Approximate Methods of Computing Landing Stresses in Aircraft.

Equivalence of Photoelastic Scattering Patterns and Membrane Contours for Torsion.

A Three-Component Force Recorder.

Three-Dimensional Photoelastic Analysis by Scattered Light.

Stress Distribution around a Hole near the Edge of a Plate under Torsion.

Response of Damped Elastic Systems to Transient Disturbances.

Electric Strain Gage Analysis of a Fifty-Foot Hortonsphere.

A Pendulum Analyzer for Mechanical Transients.

A Strain-Gage Balance System for a Supersonic Wind Tunnel.

The Photo-Grid Process for Measuring Strain Caused by Underwater Explosions.

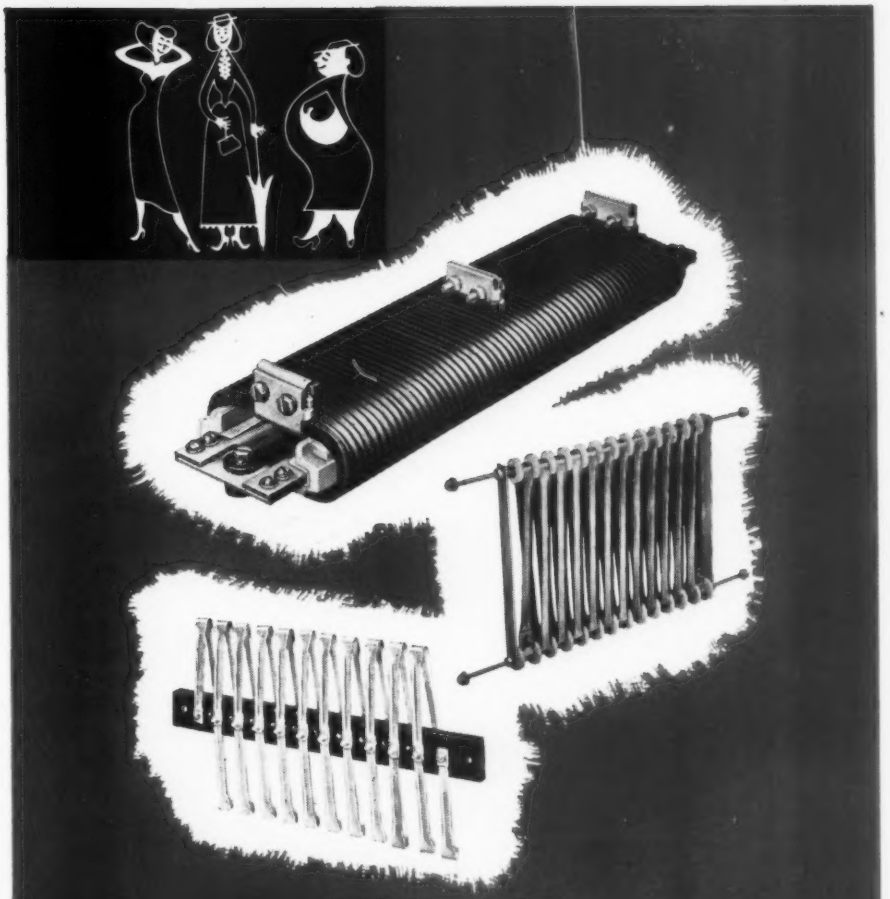
Some Evaluations of Stresses in Aneroid Capsules.

Allowable Stresses for Steel Members of Finite Life.

Theoretical and Experimental Investigation of Buckling Shock Mount.

The paper on a "Three-Component Force Recorder" describes a measuring instrument that may have special interest for design and development engineers who must measure and record forces in three dimensions.

"Allowable Stresses for Steel Members of Finite Life" contains the findings of Noll and Erickson on the



THREE
different types

Ward Leonard High Current Resistors light in weight, flexible in design, wide application

Edgeohm, Loopohm or Barohm, Ward Leonard alloy ribbon resistors withstand shock. They are for high current applications. To determine the type most suitable for a specific use—the resistance, maximum current, steps required, available space, vibration and other unusual conditions should be considered.

This is Ward Leonard "Result-Engineering". So often, by slight modification of a basic design, Ward Leonard can give you the *exact* result you want—without the *extra* cost of a special.

Write for Resistor Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

WARD LEONARD
ELECTRIC COMPANY
RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

Silicone News

DC SILICONES

The Shoemaker's Son May Go Barefoot

But when a motor manufacturer has electrical equipment that fails frequently because of high operating temperatures, he uses DC Silicone Insulation. Take an absorption type dynamometer, for example.

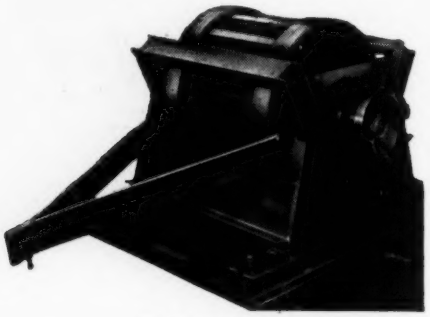


PHOTO COURTESY HOWELL ELECTRIC MOTOR COMPANY

Using a 75 h.p. frame and stator, Howell engineers designed and built this absorption type dynamometer to determine torque in electric motors. They chose this type of dynamometer because motors are easily hooked up and readings are quickly made. The idea was good but Class 'B' insulation wasn't good enough.

Average life of the windings was limited to 2 to 3 months and only motors of 75 h.p. or less could be tested without burning out the windings. To this practical problem the Howell engineers found the practical answer. After several failures they rewound the dynamometer with our Silicone (Class 'H') Insulation.

Results were even better than they hoped. The silicone insulated dynamometer has been in service now for 18 months—over 6 times the average life of Class 'B' windings—and the insulation is still in excellent condition. Furthermore, the dynamometer is being used to test motors ranging up to 150 h.p.—twice the previous capacity.

That's just another one of the many field reports that confirm the findings of our Motor Test Laboratory—DC Silicone Insulation has at least 10 times the life and 10 times the wet insulation resistance of Class 'B' under similar operating conditions. If you want more evidence of the superiority of Silicone Insulation write for leaflet G-4-H.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Atlanta • Chicago • Cleveland • Dallas
New York • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

problem of selecting allowable stresses for steel members subjected to a limited number of cycles—say less than 1,000,000. Effect of mode of stress variation, stress concentration, surface finish and their interrelations are shown by a number of diagrams. Allowable stresses for limited life for parts of various Brinnel hardness ranges is given in 18 charts.

Hydraulics

HORACE W. KING, CHESTER O. WISLER *and* JAMES G. WOODBURN. *Fifth Edition.* 351 *pages,* 6 x 8½ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $4.

Fundamental principles of hydraulics and their application to engineering problems are covered in this long standing textbook. This revision includes new material on the variation of hydrostatic pressure with altitude in a compressible fluid, on the flow of liquid in pipes, analysis of flow in pipe networks and resistance offered to the motion of objects through a fluid.

Pipes are covered in Chapter 7. Velocities, loss of head, frictional loss and similar topics will be of interest to designers. Chapter 9 on hydrodynamics contains material basic to hydraulic couplings and torque convertors.

The book is a reference on hydraulic principles. In practice, the tables of coefficients will have to be supplemented by data from other sources.

Design of Metal Cutting Tools

FREDERIC L. WOODCOCK, *Chief Tool Engineer, Hamilton Standard Propellers Division, United Aircraft Corp. First Edition.* 406 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *West* 42*nd St., New York* 18, *N. Y.* $5.

Basic principles of tool design for mass production manufacturing processes. Profusely illustrated with line drawings and photographs, this book will be a valuable reference for tool designers, production engineers and manufacturing supervisors. Explanations of the principles are sufficiently detailed to make the book valuable for use by students and teachers.

The book is divided into two parts: Part I, covering tool design fundamentals and part II describing design detals. In part I, the following subjects are discussed: Economics and standardization, elements of cutting, maintenance, inspection and sharpening. Also touched upon are: Cutting tool materials, heat treatments and cutting fluids.

Part II describes and illustrates the design details of the usual types of

Sure, most of us know that resistance welding cuts fabrication costs. Isn't Industry buying 5 times the resistance welding equipment it did before the war?

WHAT'S THAT GOT TO DO WITH THE DESIGN ENGINEER?

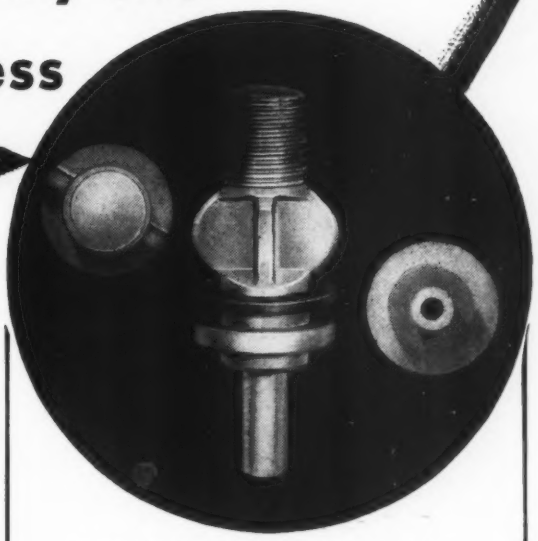
Just this: The plant can't resistance weld it unless you design it so that it can be welded—easily, cheaply, and soundly. Sound tough? It isn't really. We'll be glad to help you all we can. That's why we are running a series on "Designing for resistance welding" in the "Welding Pictorial", news-organ of "what's new in welding". Are you getting it?

Write for the last issue today. It might be the means of your saving your company thousands of $ tomorrow.

IT PAYS TO WELD

PROGRESSIVE WELDER COMPANY
3050 E. OUTER DRIVE, DETROIT 12, U.S.A.

Why this part is made by the COLD HEADED process



Copper Stud with fiber washer, actual size.

The copper stud illustrated here could be made on an automatic screw machine or by the hot forged method.

Its specifications better meet the requirements of cold heading with substantial savings and highest quality. Consider these definite advantages:

1. Saving of Metal: By the cold headed process, loss of metal runs from less than 1% to not over 10%. Loss of metal by hot forging or screw machine may run as high as 75%.

2. Close Tolerances and Fewer Operations: Since close tolerances are held, extra finishing operations are held to a minimum.

3. Cold Heading Is a Fast Operation: A cold header is a high speed, mass production machine and lends itself to long runs at great savings.

4. Uniform High Quality: Since heading is a cold working process, it reveals such imperfections in raw material as seams, cracks and inclusions. The raw material must be perfect, thus insuring that the finished product is basically sound.

5. Greater Strength: Cold working does not break or cut the flow lines of metal. It increases its resistance to shock, shear and fatigue.

6. Large Possible Savings: If the specifications of a part meet the requirements of cold heading, savings are possible in producing a high quality part through the saving of material, a high production rate with close tolerances, and low tool costs.

HERE'S WHY

- Avoids slow and costly machining of copper.
- Entire stud in one piece. Fiber washer is locked on under collar by the threads, but is free to rotate. The part made by any other method would require forcing a split washer over the thread. Fewer secondary operations.
- Saves 75% of material when cold headed instead of machined.
- Cold headed production—600 per hour. Screw machine estimated at 60 per hour.
- Produced at lowest possible cost for stronger, higher quality part meeting unusual special requirements.

Special Cold Headed Parts • Phillips Recessed Head Screws
Clutch Recessed Head Screws • Washer Screw Assemblies (Sems)
Tapping Screws • Standard Machine Screws

We will be glad to work out your requirements with you. There is an Industrial Fastener Sales representative near you. Send, now, for "A Guide to the Profitable Use of Cold Heading."

INDUSTRIAL FASTENER SALES
WATERVILLE DIVISION

SCOVILL MANUFACTURING CO.
Waterville 48, Connecticut

New York, Chrysler Building • Detroit, 6460 Kercheval Avenue • Chicago, 222 West Adams Street • Los Angeles, 2627 South Soto Street
Syracuse, Syracuse-Kemper Insurance Building • Cleveland, Terminal Tower Building • San Francisco, 434 Brannan Street

SWIFT • SURE • STURDY • SILENT • SMOOTH • STEADY

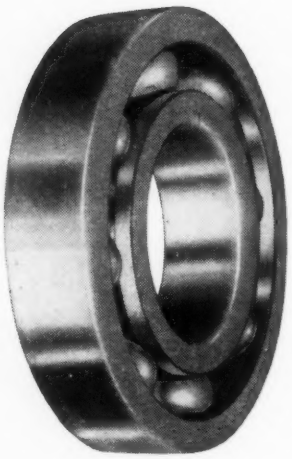
PLAN *Steady* DRAFT-HORSE DEPENDABILITY IN EVERY BASIC DESIGN

You've often remarked that no piece of equipment can be superior to its component parts...

You appreciate the broad recognition and acceptance of BCA Ball Bearings in industry . . .

You know you can tell your engineers to draw upon our half-century of experience in friction control practices, encompassing many varied fields of industry . . .

You, who insist upon continuous, full-capacity, trouble-free operation, know this can be assured by specifying BCA Ball Bearings.



BEARINGS COMPANY OF AMERICA
LANCASTER, PENNSYLVANIA

BCA RADIAL • ANGULAR CONTACT • THRUST BALL BEARINGS

cutting tools used in mass production manufacture. The following tools are discussed: Broaches, counterbores and countersinks, cutters, drills, form tools, hobs and miscellaneous tools. Other tools described are: Punches and dies, reamers, Shaper cutters, single point and threaded tools.

In addition to describing the design features of these tools, the author tells when and where to use them and illustrates how they are mounted in machine tools. Necessary specifications for ordering the tools are also given.

An appendix giving valuable standard tooling information such as tapers, keyways, reamer dimensions, form tool blanks, taps and screw threads, is included. A check list for die designers is also given in the appendix.

Introduction to Tool Engineering

HALSEY F. OWEN, *Associate Professor of Industrial Engineering, Purdue University.* 150 *pages,* 6 x 9 *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York, N. Y.* $3.60.

An excellent presentation of tool engineering fundamentals. Dealing specifically with the problems confronting the production engineer striving for economical, interchangeable mass production manufacture, this text will be of value to both technical students and engineers in the design and production fields.

Of particular interest to the design engineer is a 20 page chapter where the problems of designing for low cost production are discussed. Included are many helpful hints on design details that facilitate manufacturing operations.

Other subjects that will interest design engineers are: Manufacturing methods and equipment, methods analysis, manufacturing costs and interchangeable manufacture.

Chapters dealing with operation sheets, tooling programs, tool design and tool cost estimating are of special interest to production engineers.

This book is illustrated with photographs, line drawings and sample forms. Problems included at the end of each chapter permit its use as a reference for classroom work.

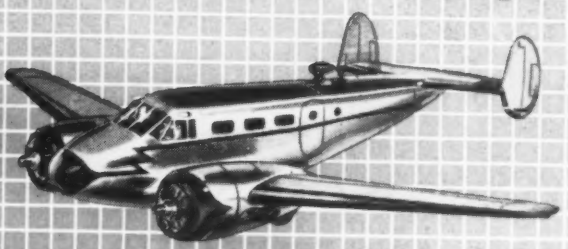
Elementary Structural Analysis

JOHN BENSON WILBUR *and* CHARLES HEAD NORRIS. *First Edition.* 523 *pages* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W. 42 St., New York* 18, *N. Y.* $6.

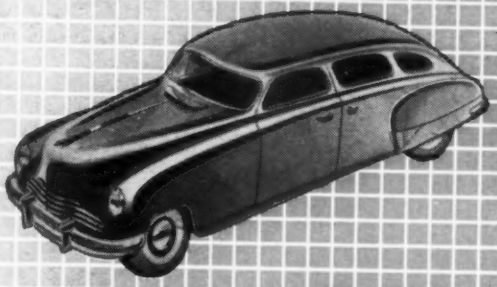
Written by professors at Massachusetts Institute of Technology, this introductory text to the subject of structural analysis has been prepared for students in civil engineering. Three

wire cloth

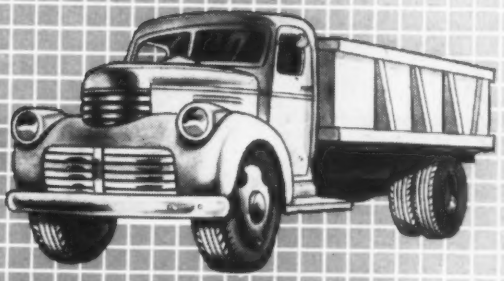
for AIRCRAFT



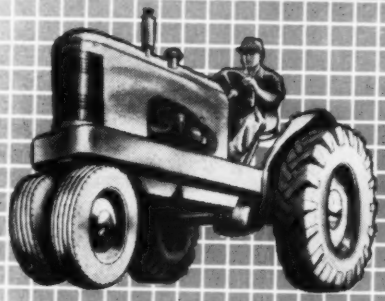
for AUTOMOBILES



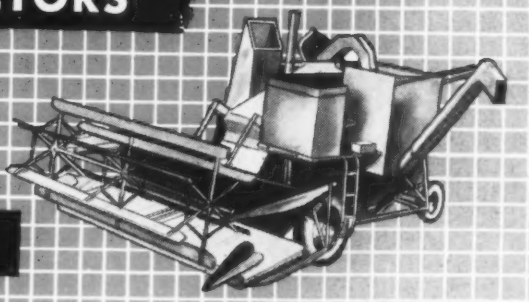
for TRUCKS



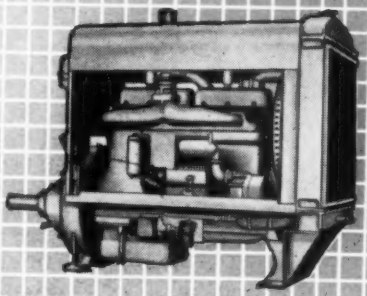
for TRACTORS



for HARVESTERS



for DIESELS



• America's progressive industries build performance reliability into these products with Reynolds Wire Cloth. Consult Reynolds Engineers.

REYNOLDS WIRE CO.
DIXON, ILLINOIS

NICKELOID

CHROME OR NICKEL PLATED ALUMINUM SHEET

HIGH LUSTER — Yes, chrome or nickel plated aluminum sheets have a brilliant beauty which add eye-appeal to any product. A lustrous chrome or nickel finish on a durable aluminum base.

LONG WEARING — Yes, chrome or nickel plated aluminum sheets are absolutely rustproof and highly resistant to corrosion, tarnish, and wear. The nickel or chrome coating gives the aluminum base a harder, long-wearing finish.

EASILY WORKED — Yes, chrome or nickel plated aluminum sheets can be stamped, formed, bent and moderately drawn without harming their mirror-like surfaces. Available in a wide range of gauges and tempers to meet all needs.

CAN BE SOLDERED — Yes, chrome or nickel plated aluminum sheets solder easily, overcoming a difficulty in this direction experienced with plain aluminum. This quality thus simplifies manufacture in many instances.

LOW IN COST — Yes, chrome or nickel plated aluminum sheets are economical to use. Because of their light weight, they offer more square footage per pound than any other commonly used metal. Economical too, because they are pre-finished and require no plating or polishing after fabrication.

The Story of Nickeloid

This year American Nickeloid Company is celebrating its 50th anniversary. In honor of the occasion we have issued an illustrated booklet which marks the significant milestones of the pioneer in the pre-finished metal industry. A copy will be sent to interested executives who write us on their company stationery.

50 Years of Pre-plated Metal Leadership

AMERICAN NICKELOID COMPANY

Established 1898

PERU 4, ILLINOIS

types of structures are exhaustively treated; beams, trusses and framed members. Also of importance to the civil engineer are the chapters on cables, gravity structures and the use of models for structural studies. More space than usual has been given to the discussions of fundamentals.

The authors proceed from fundamental concepts through the determination of loads on statically determinate and statically indeterminate structures. Classic solutions are given for many problems and a rather complete presentation of the factor method of analyzing building frames appears near the end of the book. The famous Hardy-Cross method of moment distribution is also emphasized.

Fractional Horsepower Electric Motors

CYRIL G. VEINOTT. *Second Edition, 554 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 18, N. Y. $5.*

This excellent reference book is already well known by mechanical engineers who apply fractional horsepower to their machines or equipment. It contains a minimum of mathematics and a maximum of clear-cut descriptive material accompanied by a number of easily understood illustrations. The book is not written as a design text, but as a reference for those who must apply or service electric motors.

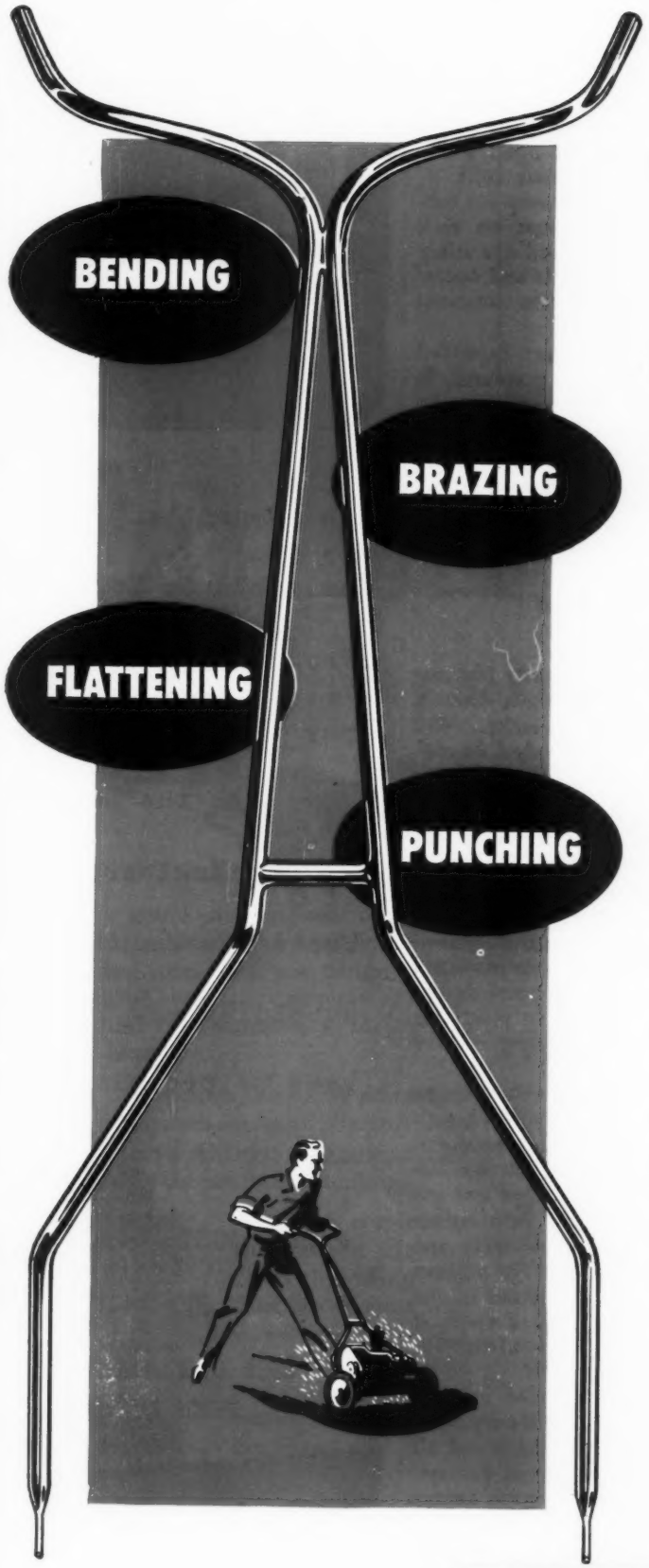
Each type of standard fraction horsepower is discussed and its operating characteristics and control requirements thoroughly defined. It is a valuable book for engineers in all fields.

Electronic Instruments

Edited by IVAN A. GREENWOOD, JR., *Research Group Leader, General Precision Laboratory, Inc.;* J. VANCE HOLDAM, JR., *Director of Research, Laboratory for Electronics, Inc., and* DUNCAN MACRAE, JR., *Teaching Fellow, Harvard University. 721 pages, 6¼ x 9¼ in. First edition, volume 21, Massachusetts Institute of Technology Radiation Laboratory Series. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. $9*

This volume covers four specific types of electronic instruments in four main subject divisions. The types of instruments are as follows: electronic analogue computers, instrument servomechanisms, voltage and current regulators, and pulse test equipment. Aside from being instruments, these units are all important adjuncts to many modern radar systems.

It has been the object of the authors to present both theoretical background and practical details of these instru-



ELECTRUNITE TUBING

Fabricated

into complete assemblies for you

This power lawn mower handle is but one of many complete tubular assemblies currently being fabricated *efficiently and economically* by Steel and Tubes Division of Republic Steel.

In addition to the operations performed on this part, Steel and Tubes affords complete up-to-date facilities for many other types of fabrication—*beading, broaching, coiling, configuring, flanging, reducing, sizing* and *upsetting,* to name but a few. From simple one-operation tubular part to complicated close-tolerance assembly, Steel and Tubes is ready to give prompt engineering assistance and quantity job quotations without cost or obligation.

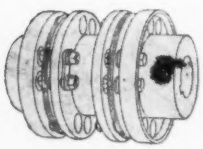
For complete information about Steel and Tubes' fabricating facilities with regard to your own specific requirements in both carbon and stainless steel tubing, write *today* to:

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

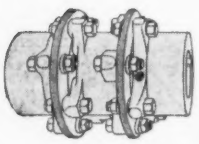
Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

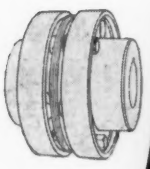
THOMAS
Flexible ALL METAL
COUPLINGS

Engineered to stand up on the toughest jobs, Thomas Flexible Couplings do not depend on springs, gears, rubber or grids to drive. All power is transmitted by direct pull.



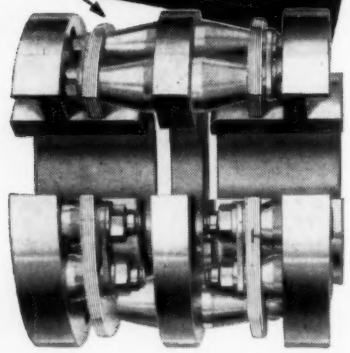
The standard line of Thomas Couplings meets practically all requirements. But if unusual conditions exist we are equipped to engineer and build special couplings.





BACKLASH
FRICTION
WEAR and
CROSS-PULL
are eliminated
NO LUBRICATION
REQUIRED!

PATENTED
FLEXIBLE
DISCS



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

Write for New Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

ments as they were known to radar engineers. The authors feel that radar uses represent but a small area of the field of utility of these units. Information is presented in such form that it will serve as foundation upon which to build larger uses for these units.

The main subject divisions are subdivided into small sections on each phase of theory, design and operation. Complete analysis of units and operations includes mathematical solutions involved.

Though efforts have been expended to completely annotate the volume, to give original soure of information, the task was too great. The information was gathered from many Army, Navy, university and industrial laboratories during the pressure of war so that credit cannot always be given. Nineteen authors have contributed to the work.

Lighting Design

PARRY MOON, *Massachusetts Institute of Technology, and* DOMINA EBERLE SPENCER, *Brown University.* 482 *pages,* 6¼ x 9¼ *in. Published by Addison-Wesley Press Inc., Kendall Square, Cambridge* 42, *Mass.* $5.

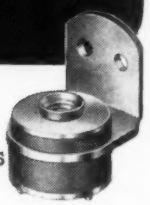
This volume was prepared with the intention of following two aims: (1) To provide a textbook on lighting, which would present fundamental principles in a quantitative manner—giving more than description—and (2) to present a comprehensive design method that can be used by practicing engineers in devising lighting systems for rooms.

The authors point out that design of lighting systems has followed path of too many engineered products. Original lighting information was derived from candles, oil lamps and gas lights and much of this information has been applied to incandescent and fluorescent system design. The authors have tried to take lighting out of the horse-and-buggy era and present it with modern ideas and knowledge for use with modern equipment.

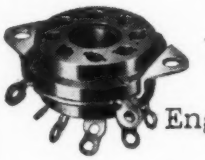
Subject matter is divided into 11 chapters covering light theory, materials, lighting units available and all factors met in the design of the systems. At end of each chapter appear summary, illustrative problems, bibliography and all tables for material covered in the chapter. Meter-kilogram-second units are used throughout the book.

Appendixes present symbols used in the text, factors for converting from units used in this volume to other units used in the field, tables of pharosage values obtained from circular and rectangular sources and fundamental interflection equations.

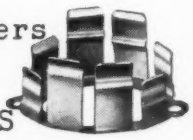
If you need Radio Parts...



in quantities suitable to Volume Production...it may pay you to call upon



the Design Engineers of United-Carr and its subsidiaries. They have helped many manufacturers



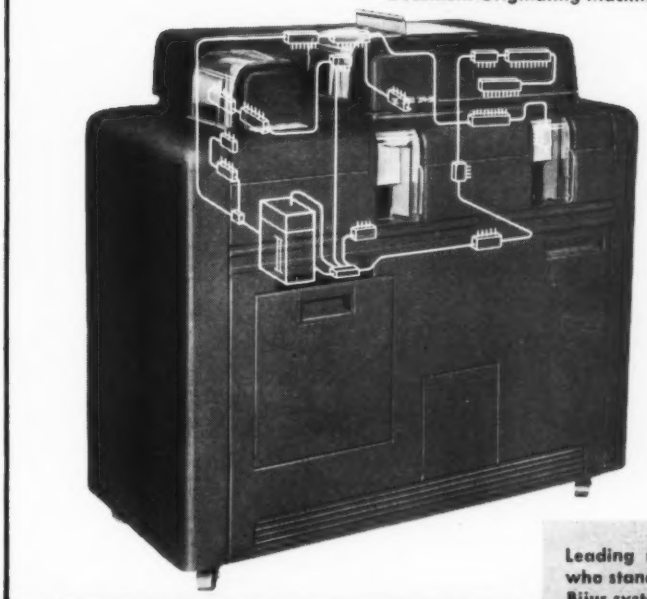
★ CUT COSTS
★ SPEED PRODUCTION
★ TURN OUT FINER FINISHED PRODUCTS

UNITED-CARR FASTENER Corp.
CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

Design for user satisfaction...

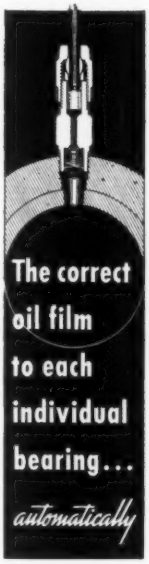
INTERNATIONAL BUSINESS MACHINES
Document Originating Machine



...by designing a "built-in" lubricating system into your machine.

You assure your customer of uninterrupted production and cut down on your servicing costs when you design a Bijur system of automatic "metered" lubrication into your machines *at the time of manufacture.*

By concentrating all oiling points into one, this system *automatically* provides a controlled oil feed for all bearings regularly while the machine is running.



By thus eliminating the human element from the oiling routine, you do away with down-time for oiling, "forgotten" bearings, and a general feast and famine condition at the bearings.

Modern Design. Building the system into the machine at time of manufacture assures improved performance by coordinating lubrication and machine design, and produces a clean-lined machine with a minimum of projecting parts.

"Metered" Lubrication. Your machine will run more smoothly on Bijur-oiled bearings over a longer period of time. The system automatically controls the oil flow through a single-line distribution system to a series of meter-units, maintaining the correct oil film *at each individual bearing.*

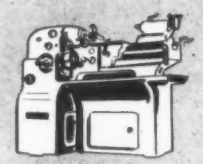
When you consider the lubrication of that new machine, call on the Bijur engineer, or write for "The Travels of Modern Lubrication." This quarterly bulletin shows how leading machine manufacturers design "built-in" lubrication into their latest models.

BIJUR

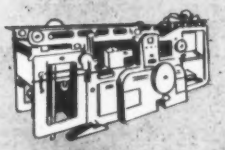
LUBRICATING CORPORATION

LONG ISLAND CITY 1 NEW YORK

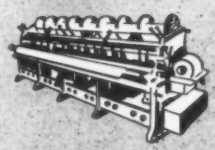
Leading manufacturers who standardize on the Bijur system.



MACHINE TOOLS
Monarch "Lathe"

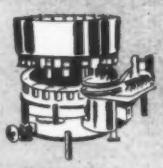


PRINTING PRESS
Miehle "Press"



TEXTILE MACHINERY
Whitin
"Knitting Machine"

PUNCH PRESSES
Bliss "Inclinable Press"



FOOD MACHINERY
Food Machinery "Filler"

Like these manufacturers, you too can "be sure with Bijur."

Design CORRECTLY in DAYS... Instead of MONTHS with STRESSCOAT

Stresscoat indications, clearly visible after load is removed, show distribution and values of stress in this casting.

It's no longer necessary for you to test design pieces over a period of months under operating conditions to determine weak points in design. You can make design corrections for maximum strength *and* lower manufacturing costs in a few days, even in hours, when you call in an experienced Stresscoat engineer.

His evaluation of Stresscoat brittle coating patterns quickly gives you an accurate overall picture of stress distribution and value. Stresscoat is the only method of stress analysis which will give you this information in one test, regardless of shape.

Stresscoat specialists will visit you for consulting stress analyses wherever your plant may be located. Write to your nearest Magnaflux Office for details of this field service.

Stresscoat St-103 Outfit

If you often work with new designs, this complete Stresscoat outfit will save you money in your stress determinations. It contains calibrating equipment, spraying units, and a generous selection of coatings.

A specialist in Stresscoat analysis from Magnaflux will work with your engineers in training them to properly use this outfit. The unit, and instruction, is yours in a "package" at $985.00, F.O.B. Chicago.

Reg. U.S. Pat. Office

MAGNAFLUX CORPORATION

Specialists in Product Inspection

5928 Northwest Highway
Chicago 31, Illinois

New York · Cleveland · Detroit
Dallas · Los Angeles

OUR READERS SAY

Standards Engineers Society

To the Editor:

We are definitely interested in learning the details concerning the working structure of the Standards Engineering Society referred to in the announcement appearing in the June issue of PRODUCT ENGINEERING.

Experience will support the belief that there is a real need for group action with regard to providing insight into the methods and extent of standardization.

Failure to take the broad over-all view and to recognize the full and permanent value of standardization may be the fault of present day education or lack of publicity. It is a story which must be reiterated again and again until the authenticity of the numerous economic advantages claimed for standardization are fully recognized.

Should it be the purpose of the society to promote standardization and provide guidance so as to avoid unwise attempts at premature or ill-planned standardization, it will be greatly welcomed by all standards engineers.

Any information concerning the foregoing will be sincerely appreciated. —GEORGE E. ROWBOTHAM,
Standards Engineer,
The American Coach & Body Co.

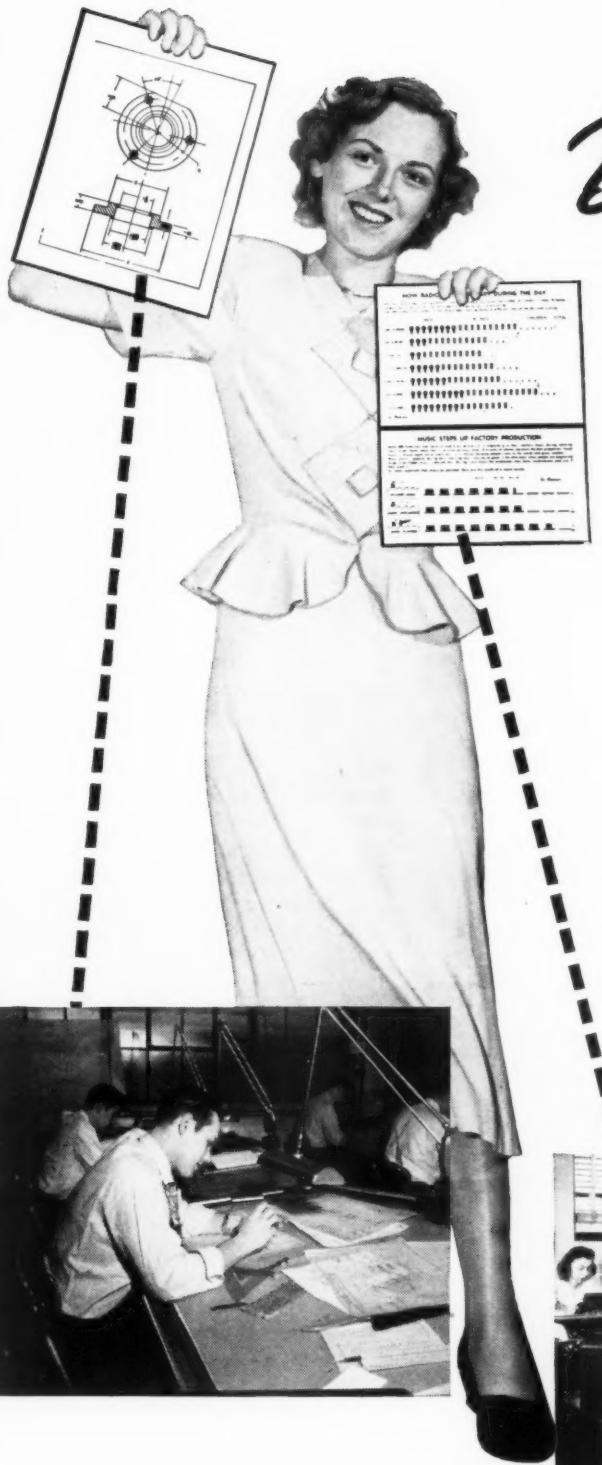
Ed.—Mr. H. R. Terhune, Secretary of the Standards Engineers Society, comments as follows:

"The Society has grown out of an informal discussion group formed in February 1947 by a number of standards engineers who felt the need for a meeting place or forum where they could discuss the problems and techniques peculiar to the development, promulgation and application of standards on a professional level.

"This need is not met by existing professional societies, since they all operate on a vertical basis, each confining its interests to one profession or one branch of industry. What was required was a horizontal organization extending, at the standards level, throughout all branches of industry and all professions. The Society has already enrolled members from twenty-six industrial concerns, manufacturing such diversified products as aerial navigation equipment, radio equipment, paints, explosives, recording instru-

To be specific, American Hard Rubber Company offers you compression and injection molding, extruding, stamping, machining, and other fabrication of Ace Hard Rubber, Okon, Ace-Saran, cellulose acetate, ethyl cellulose, polyethylene, and other plastics. A gold mine of helpful information is available free. Just write on your company letterhead for the new HARD RUBBER & PLASTICS HANDBOOK.

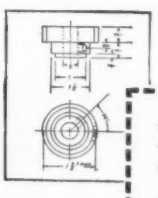
ACE Since 1851 AMERICAN HARD RUBBER COMPANY
HARD RUBBER AND OTHER IMPORTANT PLASTICS
11 MERCER STREET
NEW YORK 13, N. Y.



Double ADVANTAGES WITH BRUNING BW WHITEPRINTS!

Your engineers and draftsmen already make their drawings on translucent papers to facilitate reproduction. By using translucent or transparent materials in your general offices, too, you can get *double* advantages from Bruning BW Whiteprints! For Bruning BW Whiteprints provide greater convenience and speed when duplicate copies are needed *anywhere.* These positive prints are made directly from the master or original—in seconds, and without the use of a negative! They are exact duplicates—no chance for errors through transcription.

Bruning BW Whiteprints are exact, positive copies of anything drawn, printed, typed or written. The BW process is simple and clean—you need no darkroom, plumbing connections or exhaust ducts. BW equipment can be installed *anywhere* in your plant or office. Let us tell you the whole story of Bruning BW Whiteprints—and why they are used by so many industries and businesses. The facts are yours for the asking. Mail the coupon!



BRUNING

CHARLES BRUNING COMPANY, INC.

Since 1897

NEW YORK • CHICAGO • LOS ANGELES • And 12 Other Cities

Drafting Machines • Drafting Room Furniture • Industrial Drawing Sets • Slide Rules • Erasing Machines and many other products

CHARLES BRUNING COMPANY, INC.
4736-78 Montrose Avenue
Chicago 41, Illinois

Gentlemen: I want to know more about Bruning BW Whiteprints and equipment. Please send me information.

Name.....

Company.....

Street.....

City.....*State*.....

Sewall GEARS

CUSTOM MADE
For EVERY NEED

For best results, get in touch with Sewall engineers while your product is still on the drawing board. Close tolerances are efficiently maintained in the production of racks... sprockets... spur... spiral... bevel... Zerol bevel... worm gears. We furnish prompt estimates on any quantity.

E. B. SEWALL MANUFACTURING CO.
696 Glendale St. St. Paul 4, Minnesota.

Solve Your Design, Fabrication and Delivery Problems by
METAL SPINNING

"TEINER" offers Time and Money Savings

Metal spinning the "Teiner" way will enable you to simplify designs and speed up production. In small runs you can save the cost of expensive dies and castings.

"TEINER" is well qualified to be of assistance to you. As specialists in metal spinning for over fifty years, we are in position to offer valuable help in both design and production so that full advantage can be taken of the great savings possible through spinning, as well as the greater strength and finer quality of the parts produced. We are also equipped to fabricate commercial flange and disc heads.

An unusual and important part of "TEINER" service is the spinning of stainless steel. Here again, spinning eliminates the need for expensive castings and machining. It will be to your advantage to submit drawings or samples of your parts for a cost estimate of producing your requirements by spinning. Your inquiries are solicited.

Other "TEINER" Services

Stamping .... Fabricating .... Assembling .... Soldering .... Silver Brazing .... Lacquering .... Welding..etc. TEINER assures expert work in all metals and in any quantities exactly to specifications. Our engineers are ready to cooperate with you on your needs.

ROLAND TEINER COMPANY, INC.
TEL. EVERETT 7-7800
130 TREMONT ST. EVERETT 99, MASS.

ments, truck bodies, electrical equipment, phonograph records, air compressors, cameras and photographic film. Also enrolled are standards engineers from several government agencies in the United States and Canada, as well as executive personnel from seven technical or professional societies. Considering that formal organization was not begun until February of 1948 this growth is gratifying.

"In your letter you mention five items as being highly desired by all standards engineers, as follows:

1. Study of methods of standardization.
2. Study of extent of standardization.
3. Education in, or publicity for standardization.
4. Promotion of standardization.
5. Guidance in standardization.

"Items 1 and 5 are important objectives of the Society, which we hope to achieve through the media of papers, symposiums and group discussions. As to item 3, the importance of indoctrinating young engineers in the advantages to be obtained through good standards cannot be over-emphasized, and members of the Society have been instrumental in encouraging the faculties of several eastern colleges and universities to install courses in industrial standardization. Some of these will begin next year, provided suitable teaching personnel can be obtained.

"Items 2 and 4 do not fall within the scope of the Society's program, which is not to develop standards, but to develop the Standards Engineer. The impetus for the creation of industrial standards and the extent of such standardization are the direct interest of company-participation bodies, such as the Company Member Committee of the American Standards Association, where we are content to let them remain. Our primary interest lies in the technogolical and professional development of the Standards Engineer."

High Density Alloy

To the Editor:

We are interested in the new high density alloy known as "Hevimet", mentioned on page 107 of the May issue of PRODUCT ENGINEERING.

Could you give us information regarding properties and typical uses of this alloy and where it can be procured? —J. V. BERTRAND, *Director, Research and Development Div., Loewy Construction Co., Inc.*

Ed.—"Hevimet" is now in use as balance weights for crankshafts and in centrifugal clutches. Material has a Rockwell hardness of C 30-40 and a tensile strength ranging between 85,-

Wooden hobbyhorse form is coated with fast-bonding 3M Adhesive

3M ADHESIVES make winners of these HOBBYHORSES

Fabric "horsehide" is stretched over form and smoothed in place

Applying fabric "hides" to these hobbyhorses was formerly a long, tedious tacking operation. Also, the tacks spoiled the natural appearance of the "hide" and frequently came loose under hard use.

Switching to 3M Adhesives doubled each worker's output and produced a lifelike job that stays permanently bonded in any temperature, under all kinds of wear.

3M ADHESIVES replace bolts, screws, lacings, rivets

Manufacturers everywhere are cutting assembly costs, producing better-looking, lighter, more durable products with 3M Adhesives. The 3M Company supplies adhesives in more than 1,000 formulas, each tailored to different manufacturing requirements. Whatever your fastening problem . . . metal to metal, rubber to glass, vinyls to wood . . . chances are there's a 3M Adhesive to do it.

Our booklet "3M Adhesives in Industry" is packed full of interesting case histories—may suggest ways you can cut your costs, too. Send the coupon for your free copy today.

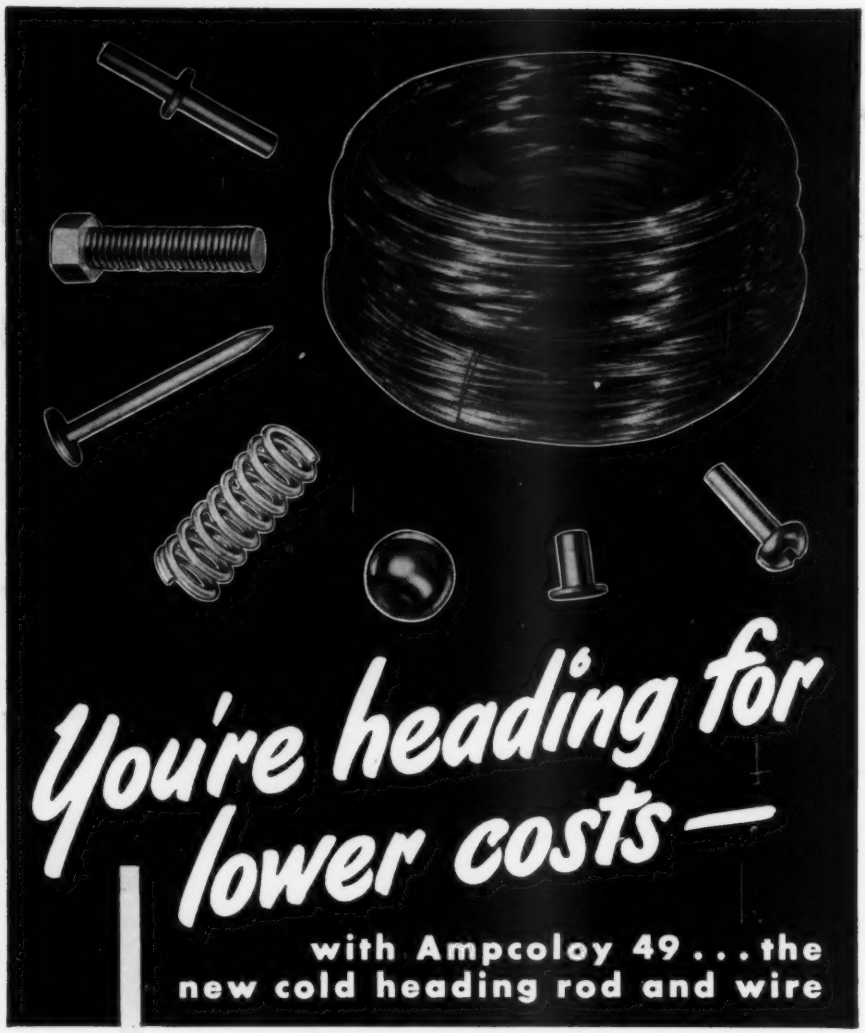
3M ADHESIVES

ANOTHER 3M COMPANY PRODUCT

Made in U.S.A. by **MINNESOTA MINING & MFG. CO.**
ADHESIVES AND COATINGS DIVISION
411 Piquette Avenue, Detroit 2, Michigan • General Offices: St. Paul 6, Minnesota

MINNESOTA MINING & MFG. CO. PE 948
St. Paul 6, Minnesota
Please send me free copy of your booklet, "3M *Adhesives in Industry.*"

Name.....Title.....
Company.....
Address.....Zone..State.....
City.....



. . . . This new aluminum bronze alloy combines ductility for cold heading and high strength-weight ratio for economy

HERE'S the first real answer to your demand for an aluminum bronze suitable for cold heading — Ampcoloy 49. It is alloyed specifically to provide the ductility that cold heading requires. Light in weight and strong, as are all aluminum bronzes, Ampcoloy 49 is still further improved by cold working.

You can get Ampcoloy 49 as extruded solid rod in diameters up to 3", or in 100-pound coils of cold-heading wire, sizes from .125 to .420 gauge.

Use Ampcoloy 49 for economical cold-heading production of bolts, rivets, screws, and similar fastenings. Take advantage of its excellent spring characteristics, its corrosion resistance, and its weldability. It can be cold-coined, cold-forged — and annealed, if it is desirable to change its physical properties. And in every application, you have the advantage of the clean, sound grain structure and close tolerances delivered by the extrusion process. For complete information on Ampcoloy 49, write for Bulletin 88.

Ampco Metal, Inc.
Dept. PE-9, Milwaukee 4, Wis.
Field Offices in Principal Cities

000 and 115,000 psi, is machinable and corrosion resistant, and can be soldered or brazed. It is produced at the Pittsfield, Mass. plant of the General Electric Company.

Resin Impregnated Asbestos Sheeting

To the Editor:

Please refer to page 106, "Progress in Review", of the May issue of PRODUCT ENGINEERING, right hand column.

I am interested in obtaining the address of a supplier for the new laminate "Fosterite" made from asbestos sheeting impregnated with an alkyd-vinyl resin.

There is also a new laminate made from wood fiber and available in sheet form that will withstand temperatures in excess of 500 deg. Fahrenheit. I would appreciate any information about this product.

—JOHN R. GOMERSALL,
Research & Development Engineer,
Toastmaster Products Div.,
McGraw Electric Co.

Ed.—The "Fosterite" resin is manufactured by Westinghouse Electric Corp., Pittsburgh, Pa.

As the editors are not familiar with any heat resistant sheet laminates made of wood fiber, they would appreciate hearing from readers familiar with such products.

Patents and the Engineer

To the Editor:

We would like to mention the article "Patents and the Engineer" from the June number of PRODUCT ENGINEERING in a coming issue of *Results From Research.* This bulletin is distributed by twenty-two banks in various parts of the country to their industrial customers and prospects.

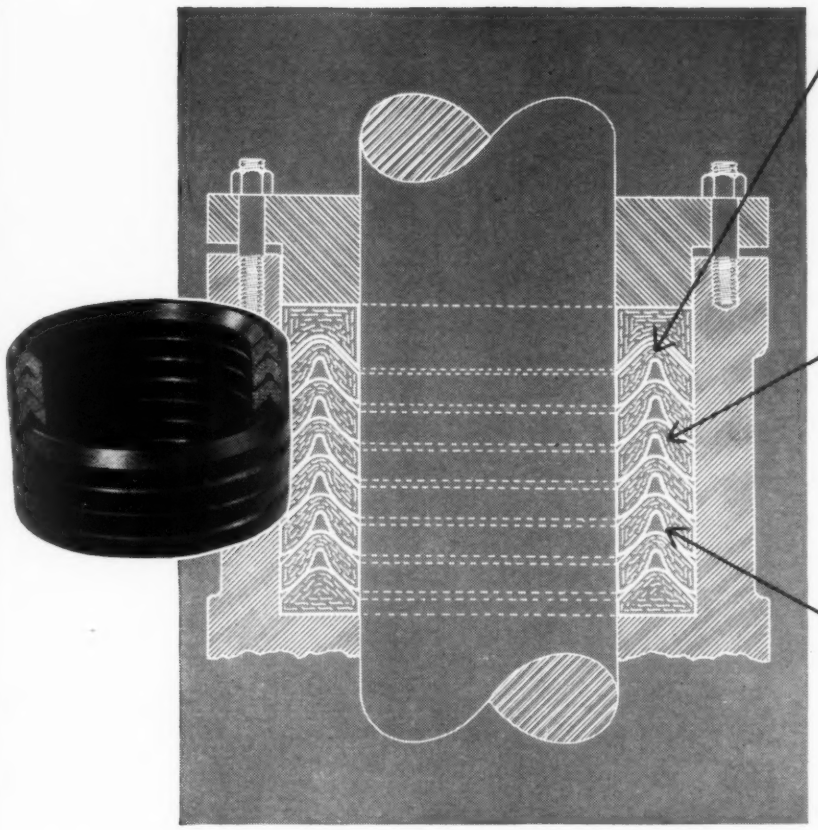
In order to take care of requests from our readers, we would need 250 copies of this reprint. Would you please let me know if this quantity is available?—EDWARD S. JOHNSON, JR.,
Staff Member,
Results From Research

To the Editor:

This is a word of congratulation concerning your excellent article, "Patents and The Engineer," in the June issue of PRODUCT ENGINEERING. I hope this will be read and digested by the engineering profession. In our practice we find that engineers are rather lacking in a knowledge of the basic principles of patents. The strong similarity of the United States practice

Specify

. . . R/M VEE-FLEX PACKING RINGS



R/M Vee-Flex packing rings insure a positive and long-lasting seal against fluids. Different types are available to meet special conditions, as in the food, chemical and oil industries. Rings are manufactured in diameters up to several feet and with annular width graduated from ¼" to 1½".

Vee-Flex rings nest together so that several rings can be fitted into a shallow stuffing box. Each ring operates as a separate seal to control pressure and the greater the number of rings in a set, the greater the effectiveness of the seal and the longer the service life.

Vee-Flex rings are used successfully on all types of oscillating, reciprocating and rotating shafts, on valve stems, airplane shock absorbers, hydraulic presses and elevators, triplex pumps, inside-packed pumps, accumulators and telemotors.

For full information write for your free copy of the latest Vee-Flex bulletin.

***IT'S "PACKED WITH SATISFACTION" WHEN YOU USE* R/M**

RAYBESTOS-MANHATTAN, INC.

ASBESTOS TEXTILE & PACKING DIVISION

Manheim, Pa. • Bridgeport, Conn. • North Charleston, S. C. • Passaic, N. J.

R/M

NONE FINER!

High precision, automotive type gears produced by Fairfield are given the benefit of every modern facility and skill for producing FINE GEARS. This is why many makers of machine tools . . . agricultural implements . . . powered vehicles . . . construction machinery . . . printing presses . . . engines . . . motors . . . stokers and pumps regularly depend on Fairfield for their gears.

If you use gears in the products you build, check with Fairfield. Submit your gear problems for FAIRFIELD ENGINEERING SERVICE.

Fairfield Manufacturing Co.
307 So. Earl Avenue, Lafayette, Indiana

FAIRFIELD for FINE GEARS

MARTIN-HUBBARD CORPORATION

Engineering Consultants

Computers — Servomechanisms

Instrumentation for Nuclear Research

Applied ultrasonic research and development

Design and construction of scientific instruments to your performance specifications

Complete engineering of original or unique electrical and mechanical devices and machinery

Technical reports

11 BEACON STREET

BOSTON 8, MASSACHUSETTS, U. S. A.

Telephone: CApitol 7-6990 Cable Address "MARHUB-Boston"

with our own will make this article of extreme value in Canada as well.

We read PRODUCT ENGINEERING regularly and find that the high quality of its articles gives us a good grasp of current patent developments.

—W. R. MEREDITH, *Barrister, Ottawa, Canada*

Brake Lining Cement

To the Editor:

We would appreciate your advising us from whom we can obtain additional information on a resin that is available and suitable for attaching brake linings to brake shoes.

—F. W. KLINE, *Buyer, Westinghouse Electric Corp.*

Ed.—The B. F. Goodrich Company make a synthetic resin called Plastilok 601 which is suitable for this purpose.

Vinyl-Coated Wire

To the Editor:

Will you please forward me further information with regard to "Spiralon" color-coded wire as mentioned on page 106 in the April, 1948, issue of PRODUCT ENGINEERING?

—H. W. BISKEBORN, *Rod and Bar Div., The Permanente Metals Corp.*

Ed.—Write to Surprenant Electrical Insulation Co., Boston, Mass.

British Hydromechanics Association

To the Editor:

We derive a considerable amount of interest from every issue of PRODUCT ENGINEERING which reaches us. The current issue is no exception.

On page 152 you mention that leading British manufacturers of hydraulic machinery have recently formed the British Hydraulic Research association.

Please let us have further particulars of this newly formed Association, together with the name of the secretary and the address, as we would like to correspond with them.—J. H. MILLAR, *President, Engineering Developments, Inc.*

Ed.—We are sorry that we cannot give you the name of the secretary of the British Hydromechanics Association but their address is 79 Petty France London S. W. 1, England.

The Director of Research for this Association is L. E. Prosser—for the past nine years Principal Scientific Officer in charge of Fluid Mechanics Section in the Engineering Division of Britain's National Physical Laboratory at Teddington.